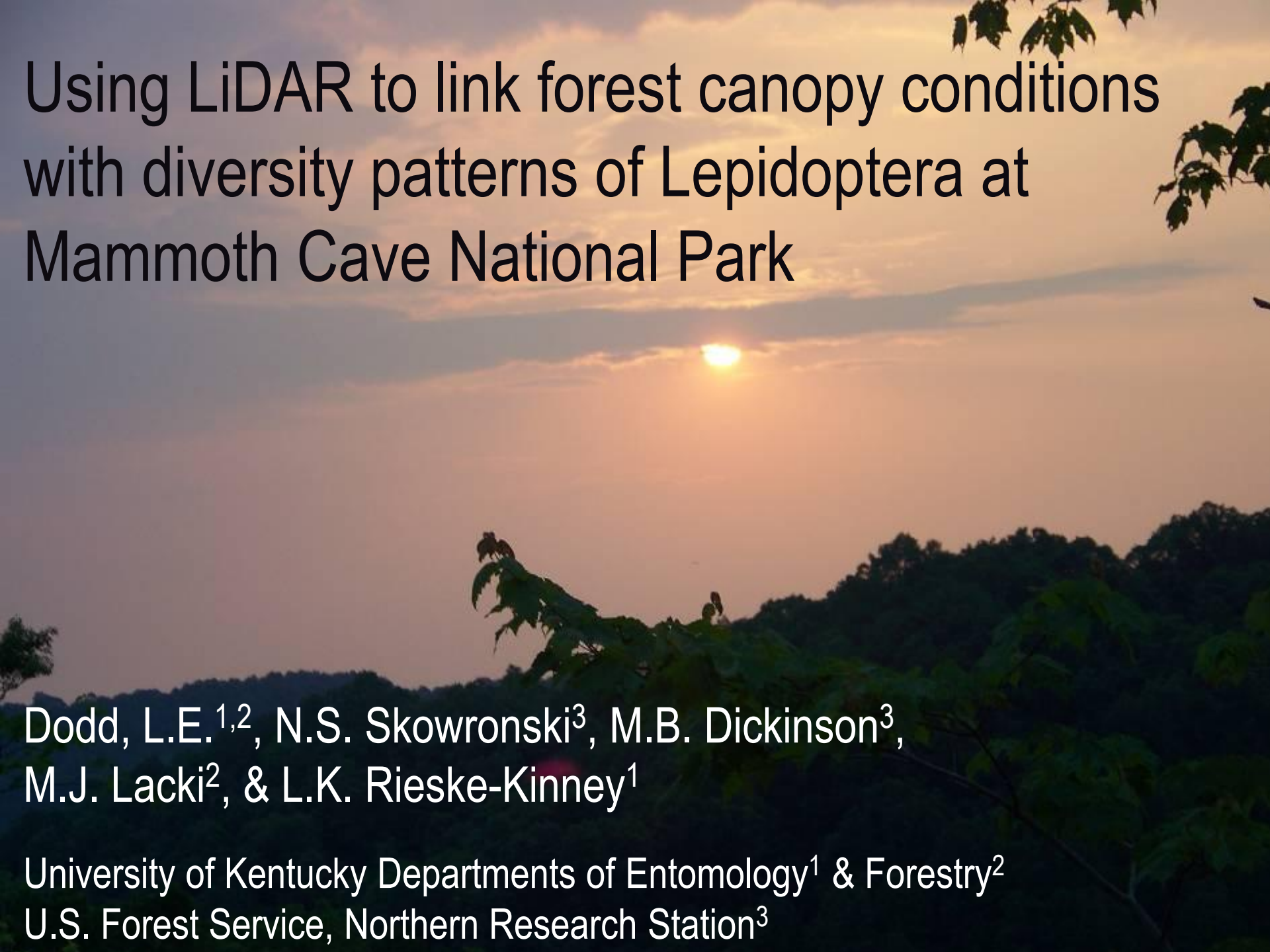
Using LiDAR to link forest canopy conditions with diversity patterns of Lepidoptera at Mammoth Cave National Park



Dodd, L.E.[1,2], N.S. Skowronski[3], M.B. Dickinson[3], M.J. Lacki[2], & L.K. Rieske-Kinney[1]

University of Kentucky Departments of Entomology[1] & Forestry[2]
U.S. Forest Service, Northern Research Station[3]

Remote Sensing & Biodiversity

- Large-scale patterns
  - Feasibility[1]
  - Necessity[2]

[1]Skowronski et al. 2007. Remote Sens. Environ. 108: 123-129.
[2]Lesak et al. 2011. Remote Sens. Environ. 115: 2823-2835

Lepidopteran Diversity

Function & Role in Eastern Forests

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- Variable occurrence across habitats[1]
  - Indicator species, responsive to forest management

[1]Summerville & Crist. 2008. Can. Entomol. 140: 475-494.

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- Conspicuous members of the community
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Lepidopteran Diversity

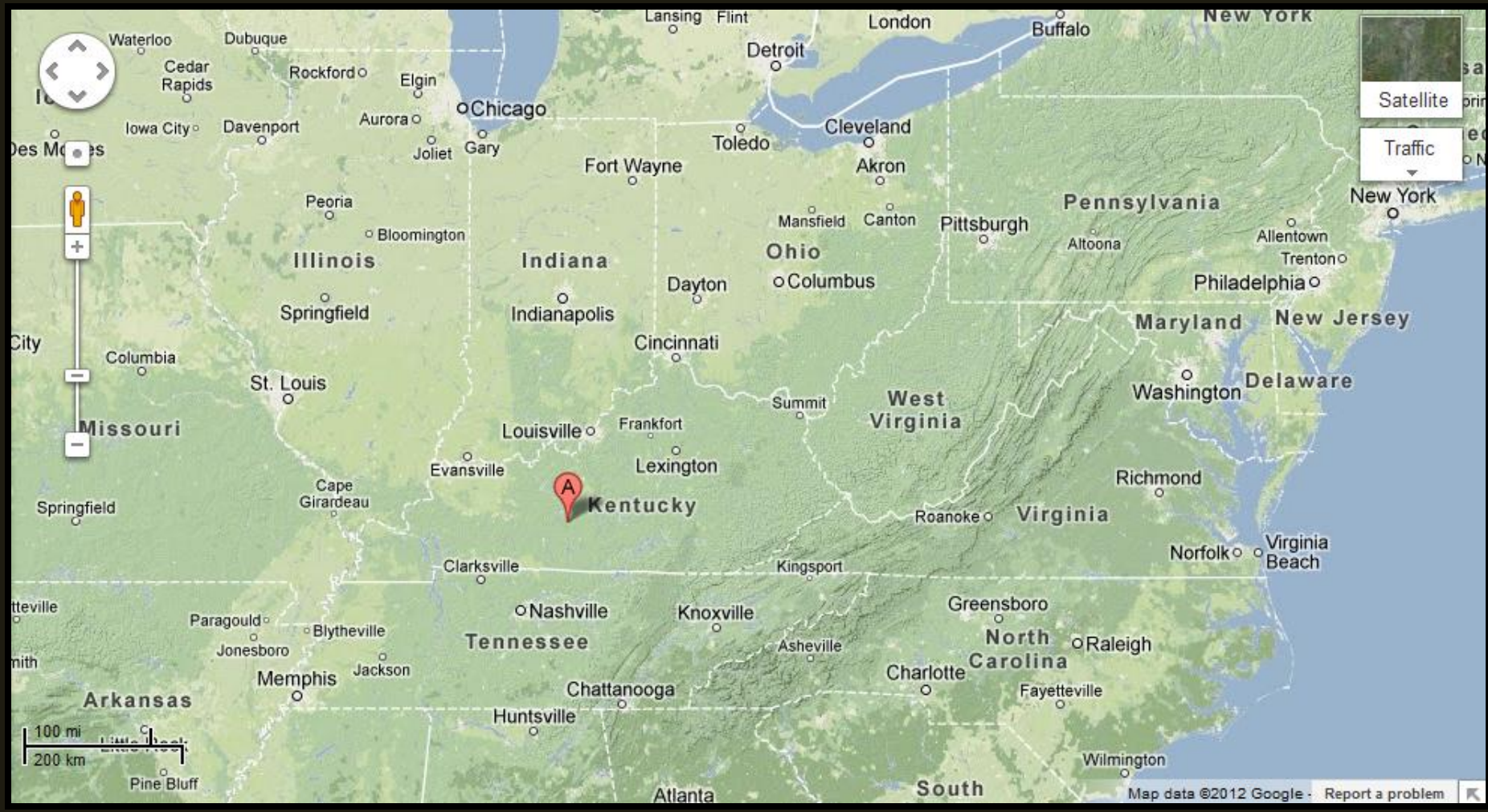
Function & Role in Eastern Forests

- Variable occurrence across habitats[1]
  - Indicator species, responsive to forest management
- Conspicuous members of the community
  - Major herbivores[1], a major prey source[2]

[1]Summerville & Crist. 2008. Can. Entomol. 140: 475-494, [2]Lacki & Dodd. 2011. in USFS Gen. Tech. Report S-145.

Methods

Mammoth Cave National Park



Methods

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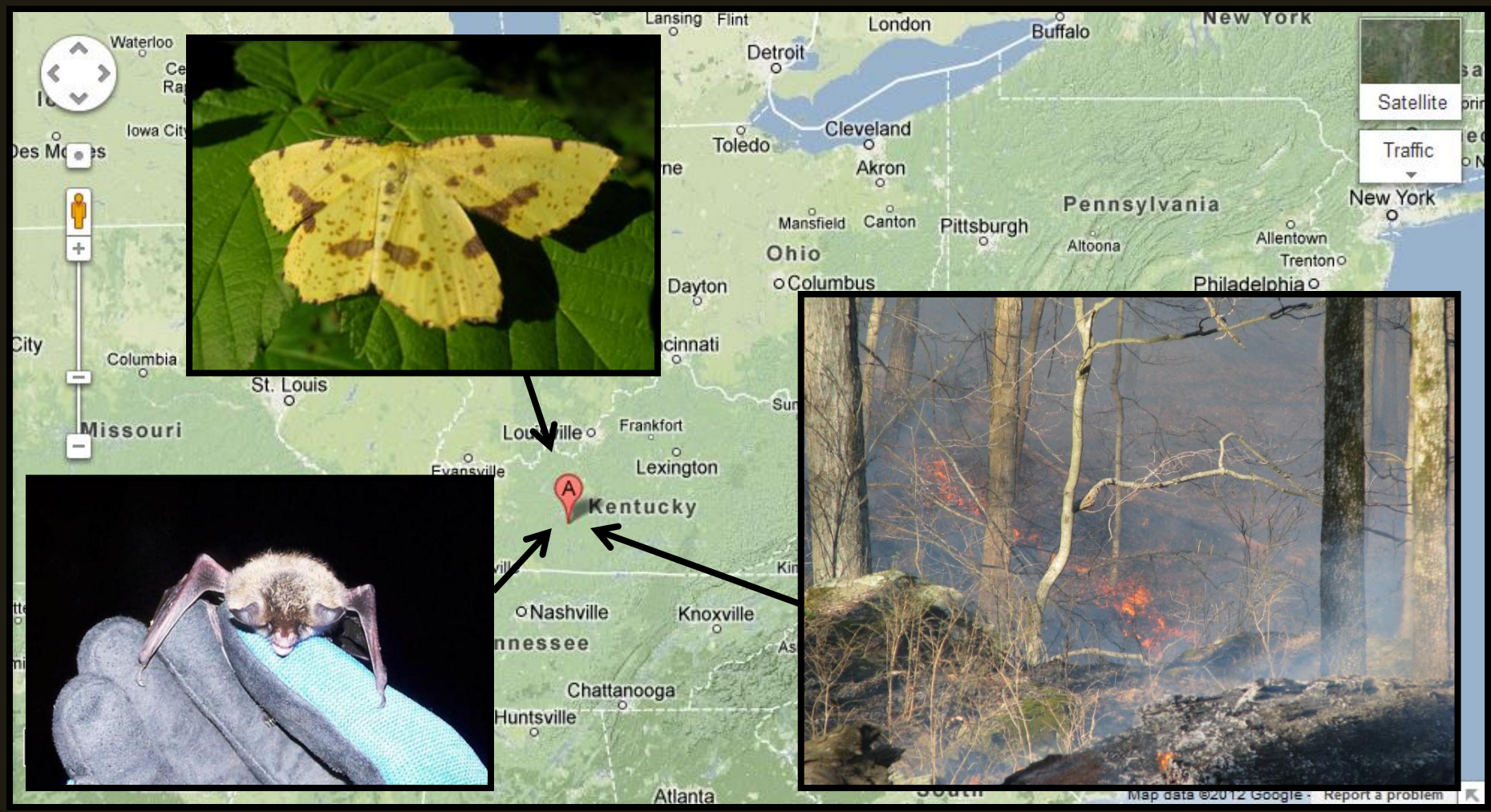

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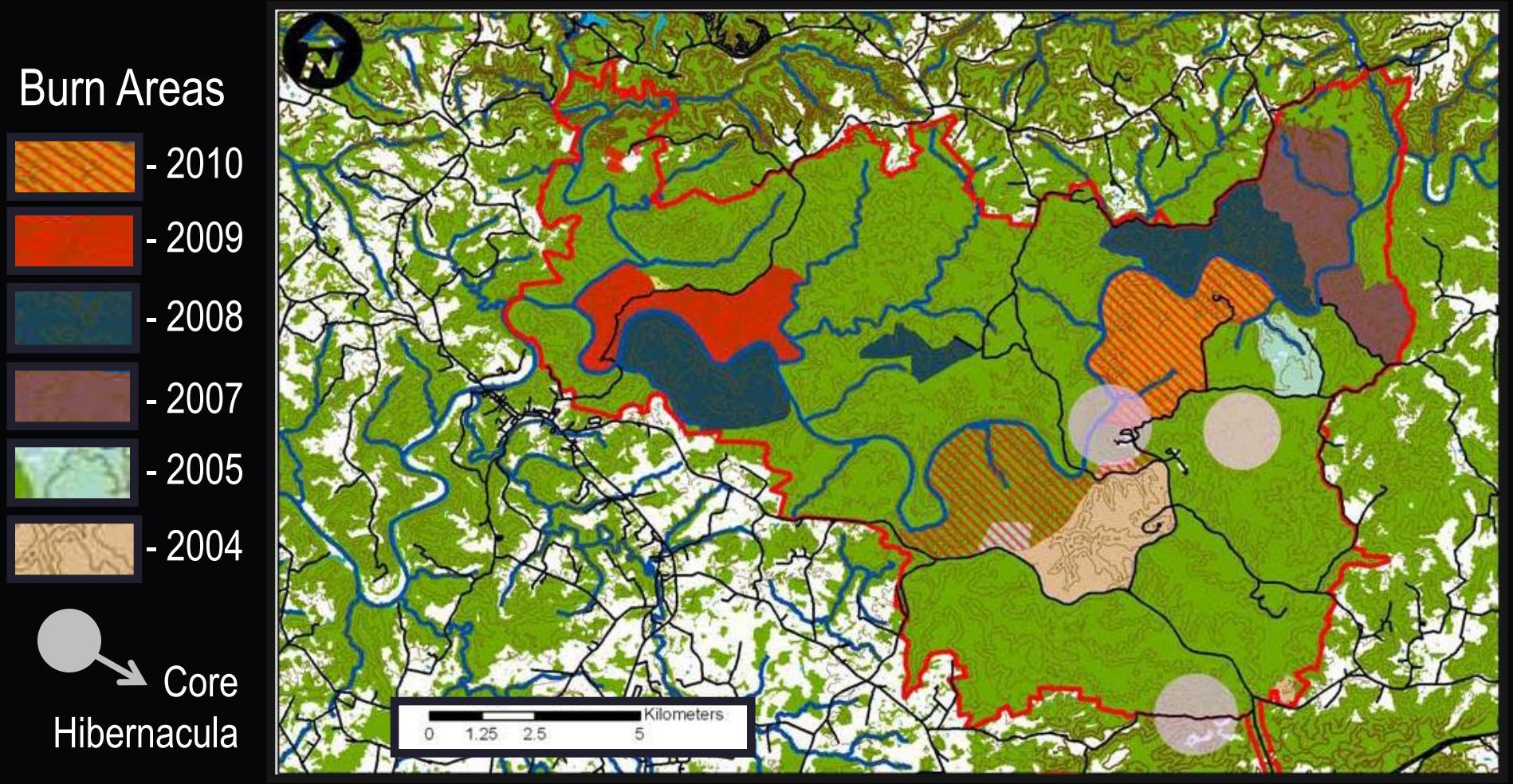

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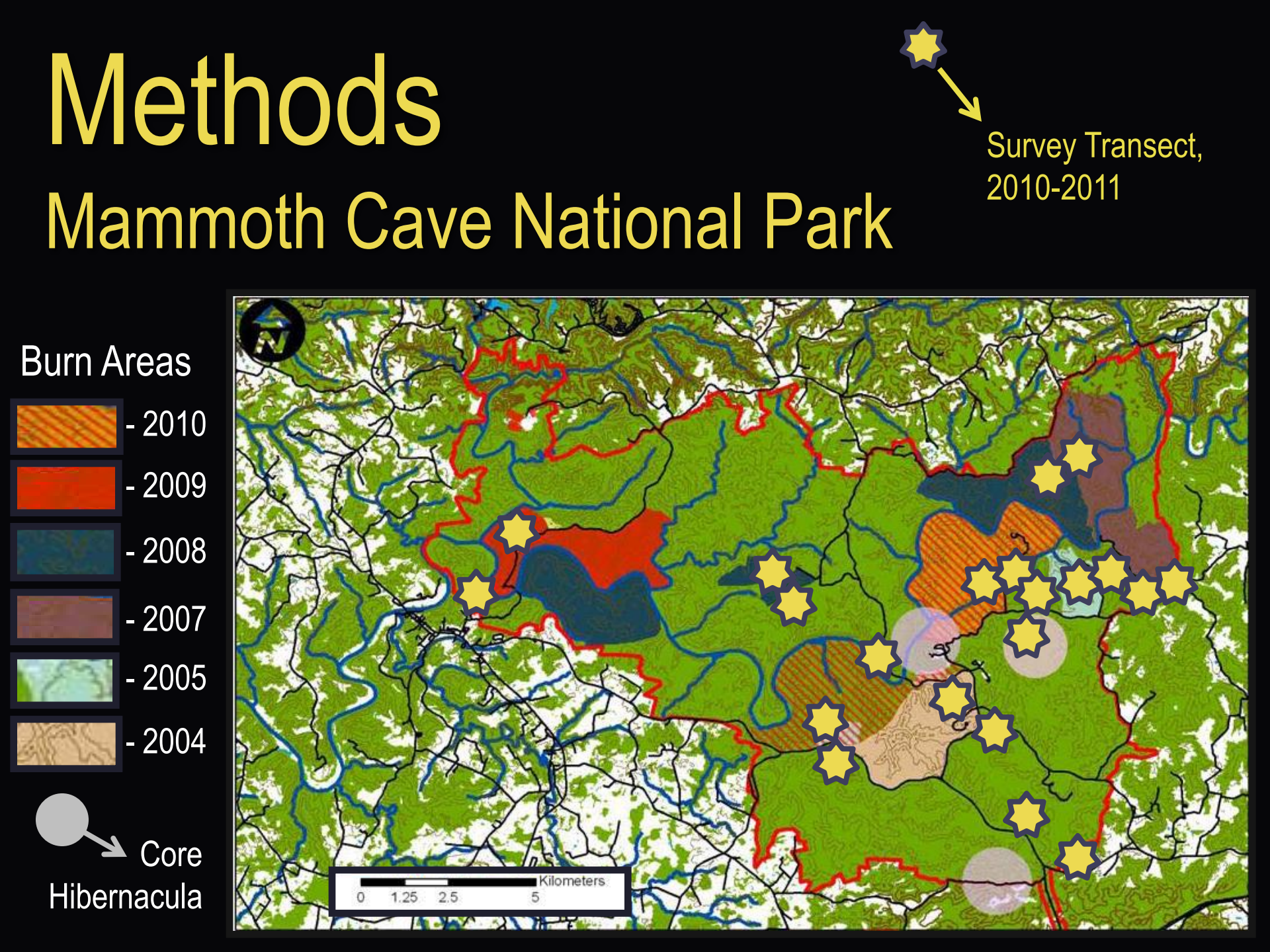

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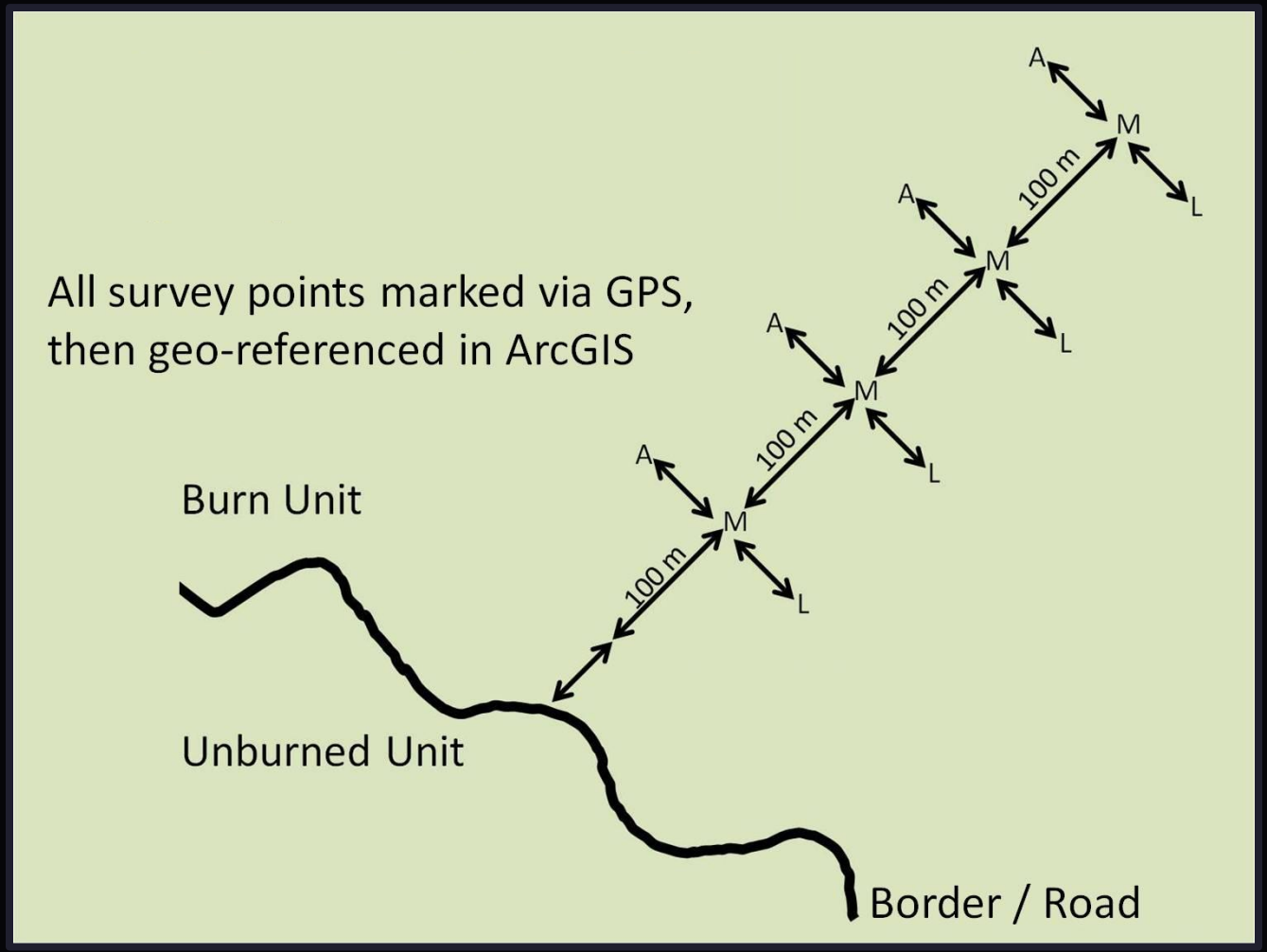
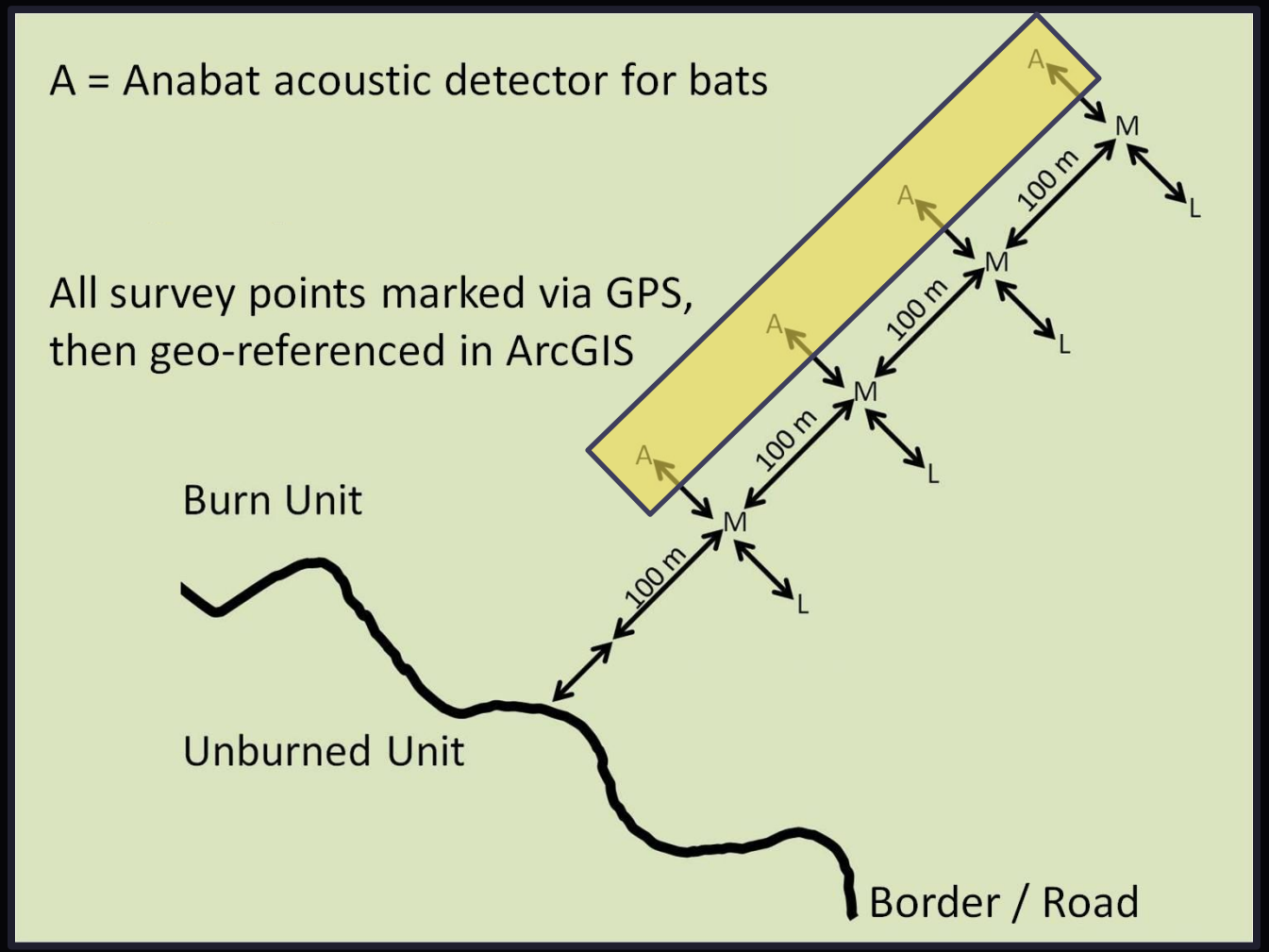


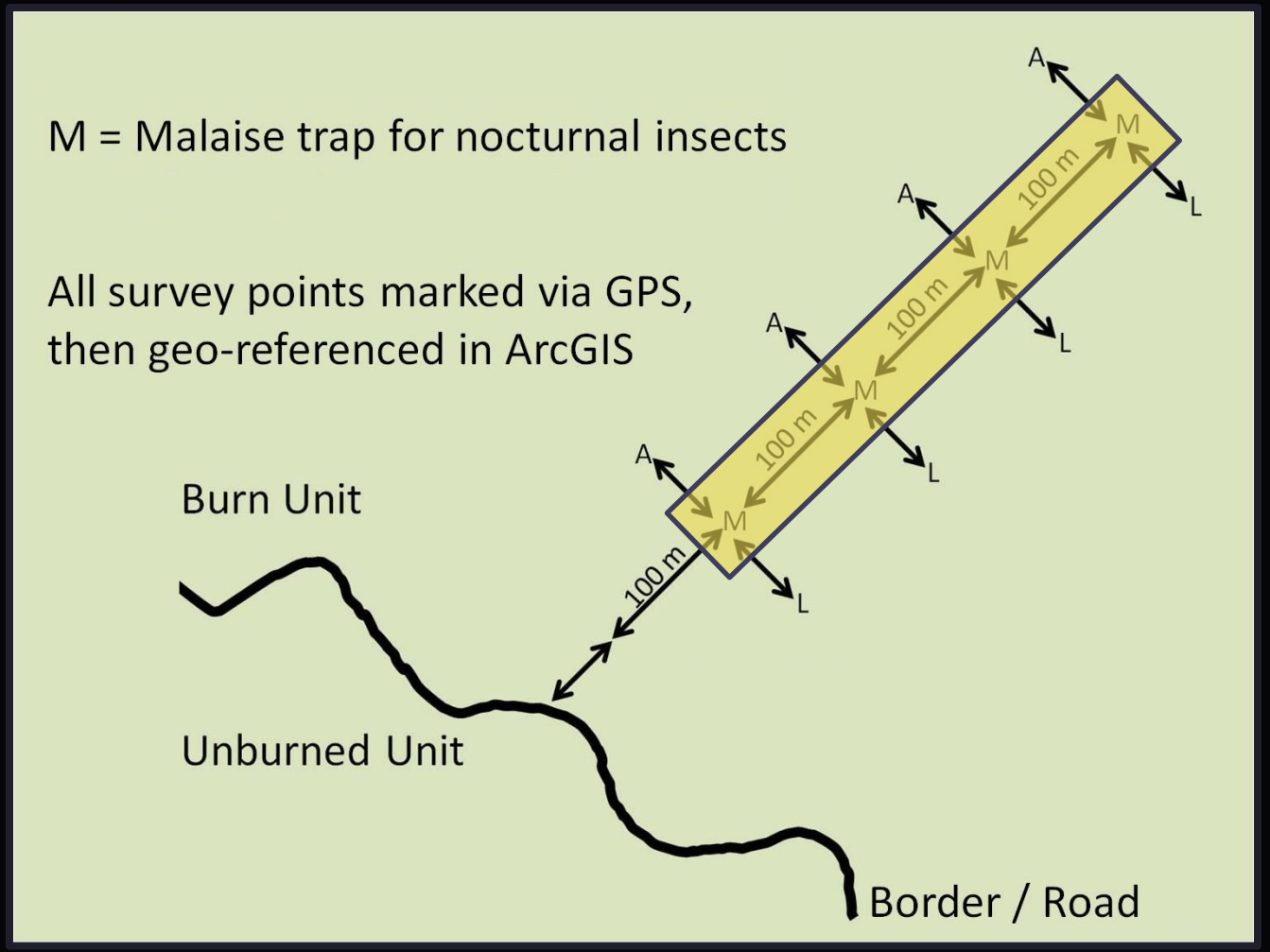
Methods

Mammoth Cave National Park



Methods

Mammoth Cave National Park



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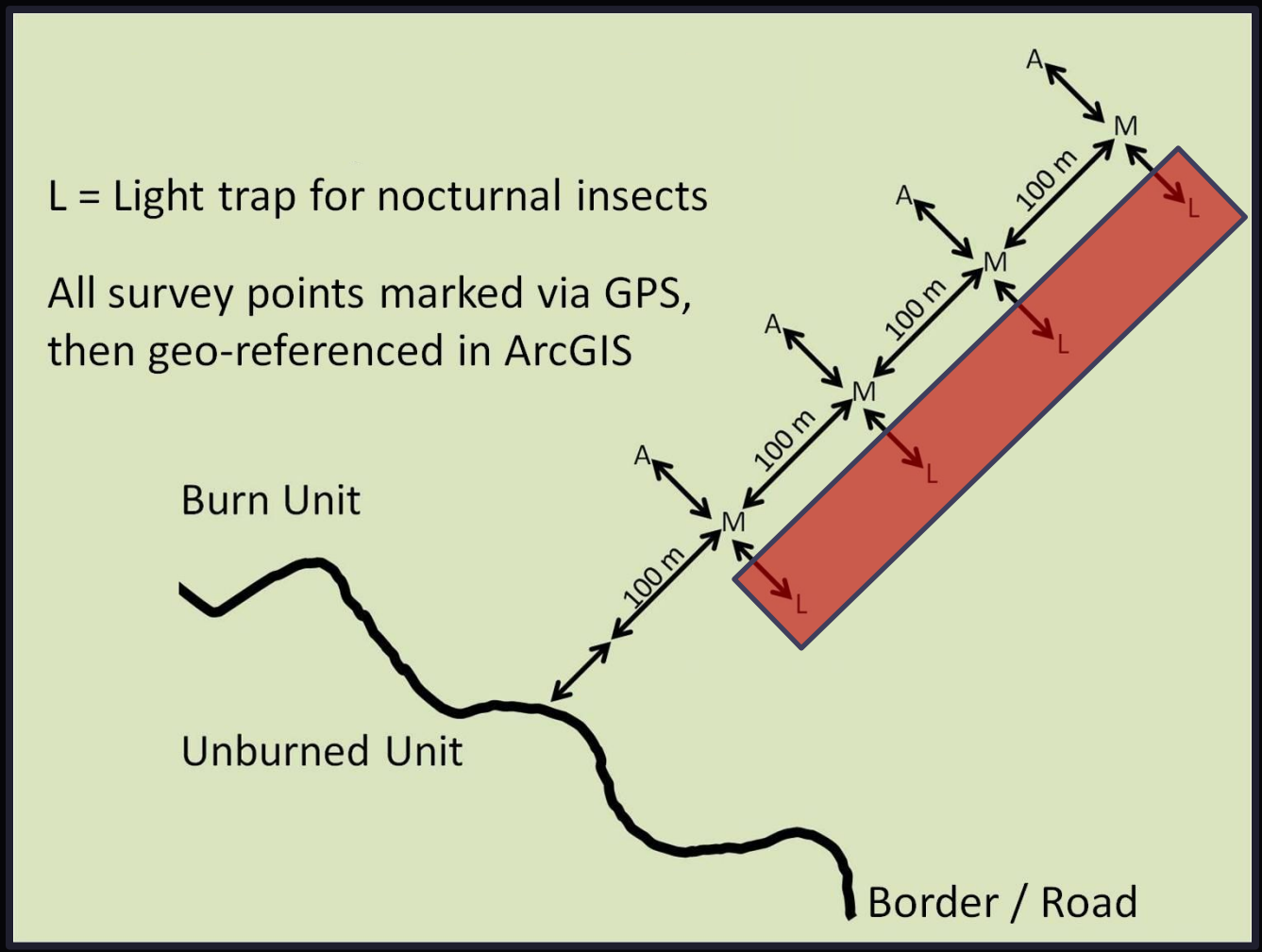
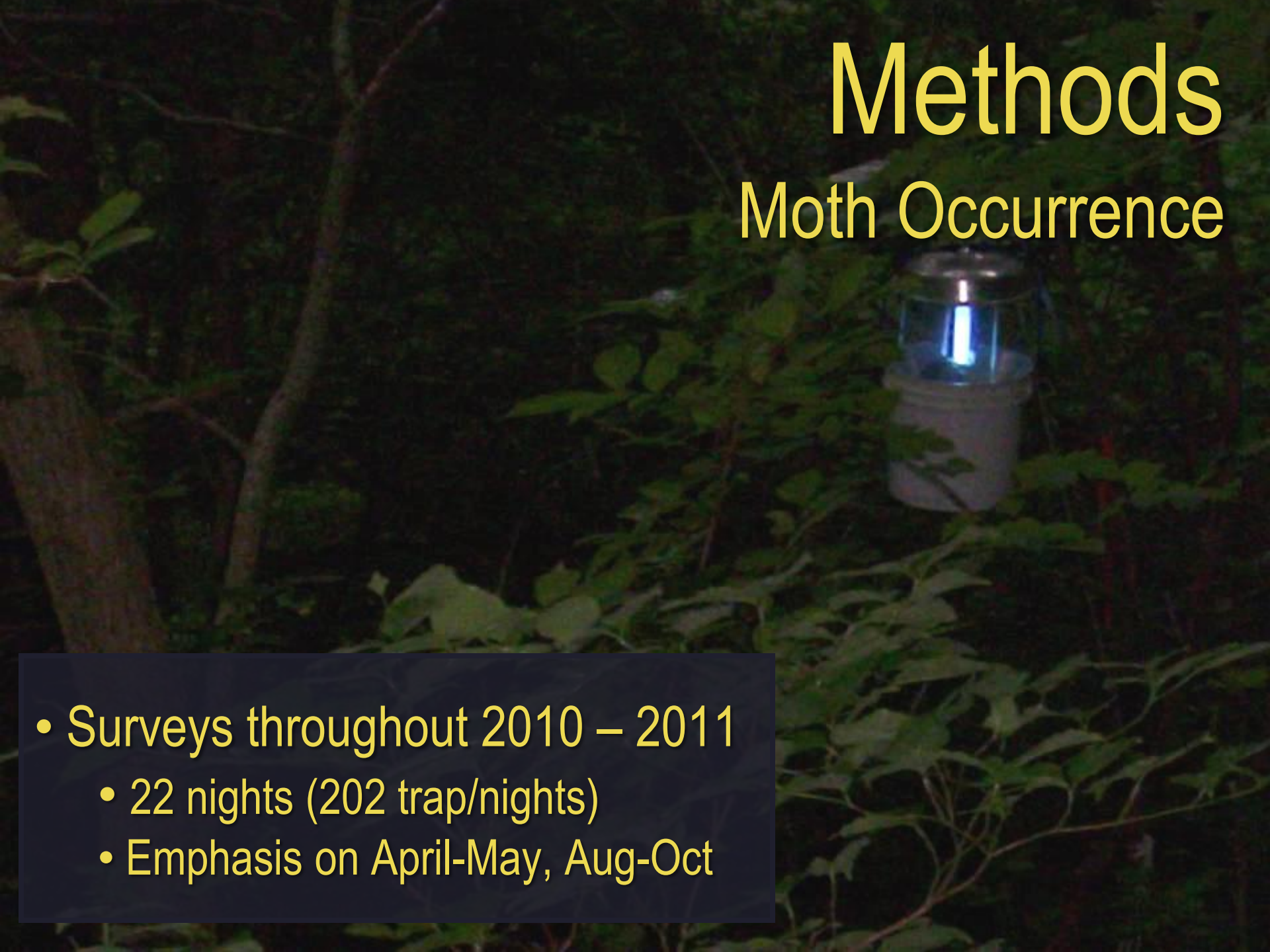
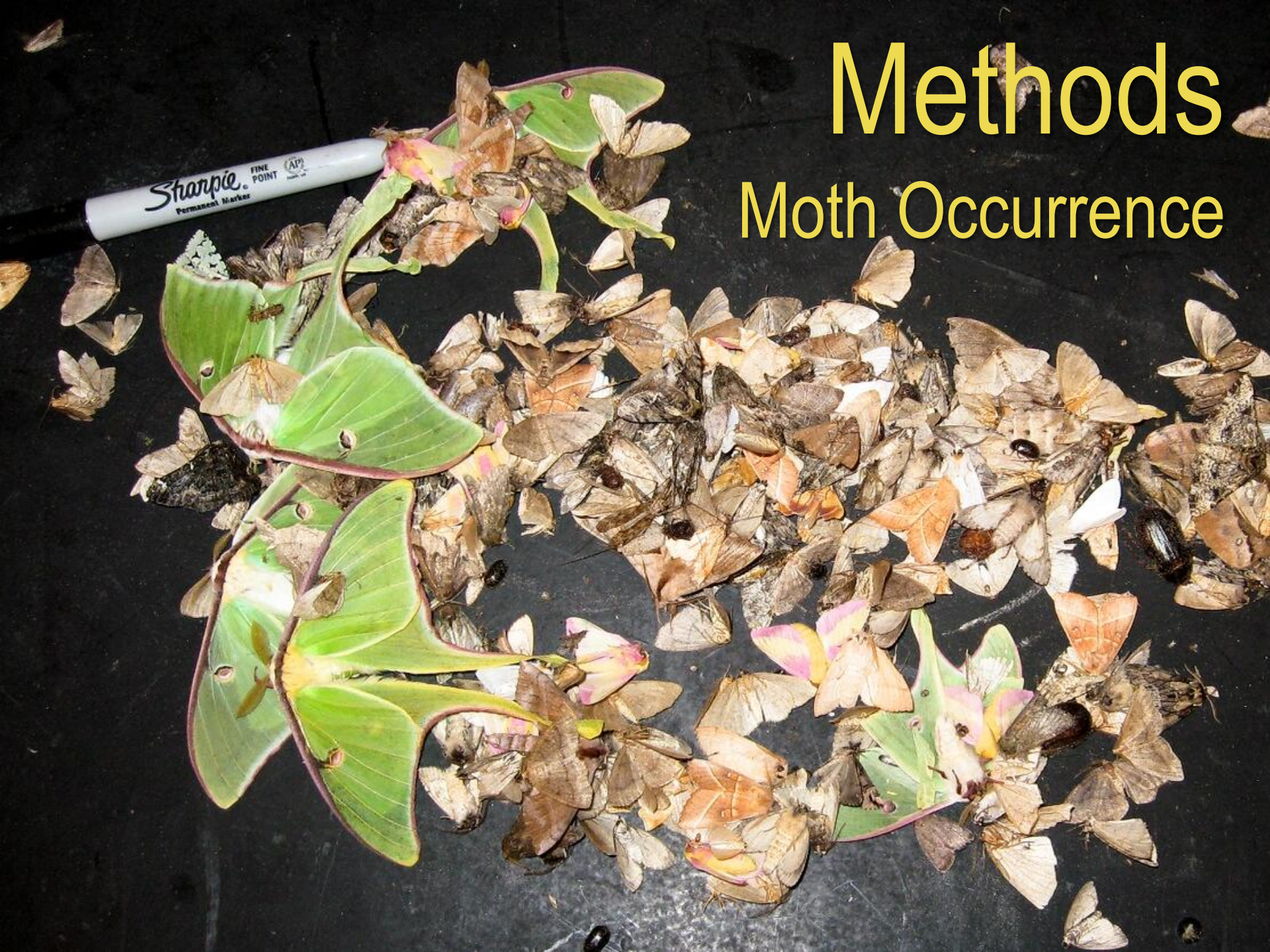


Methods

Moth Occurrence



- Surveys throughout 2010 – 2011
  - 22 nights (202 trap/nights)
  - Emphasis on April-May, Aug-Oct



Methods

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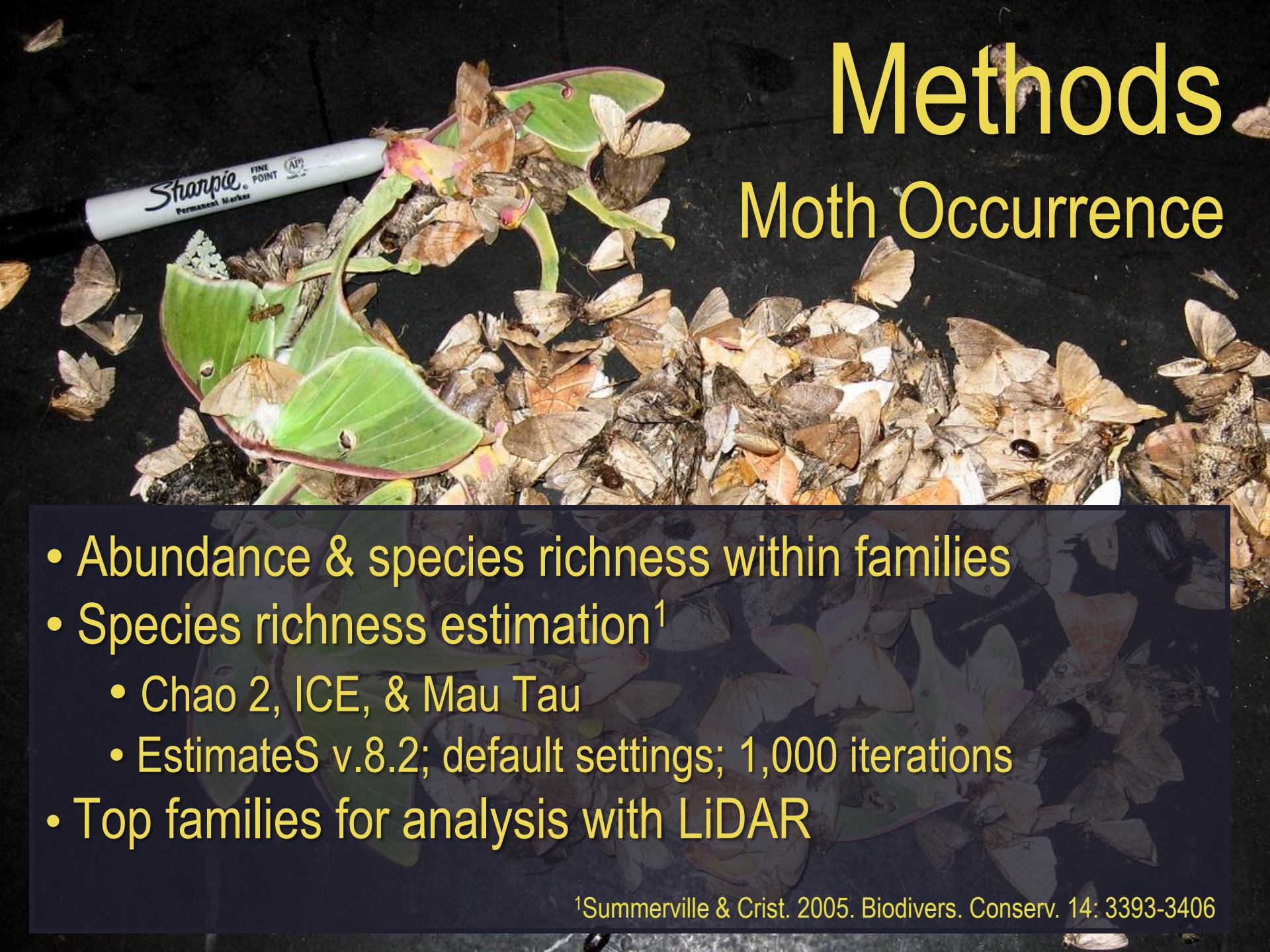


Methods

Moth Occurrence

- Abundance & species richness within families
- Species richness estimation[1]
  - Chao 2, ICE, & Mau Tau
  - EstimateS v.8.2; default settings; 1,000 iterations
- Top families for analysis with LiDAR

[1]Summerville & Crist. 2005. Biodivers. Conserv. 14: 3393-3406

Methods

LiDAR Survey

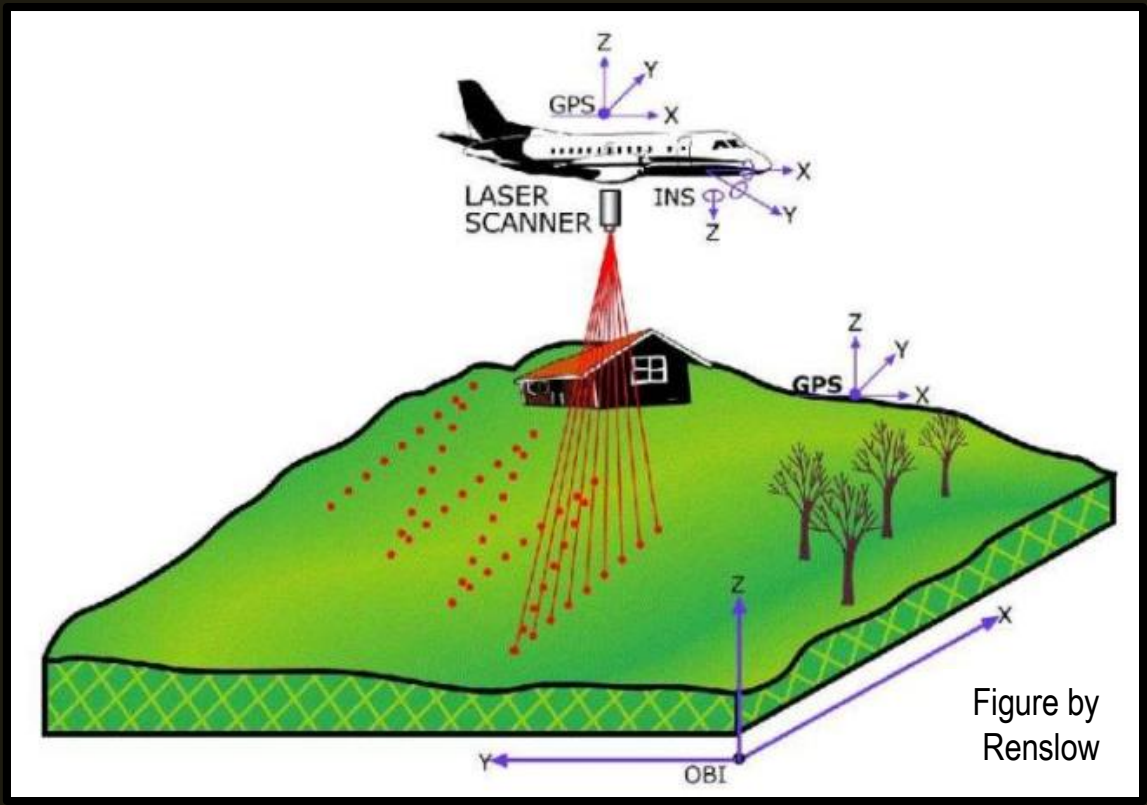


Figure by Renslow

- LiDAR = “Light Detection and Ranging”

Methods

LiDAR Survey

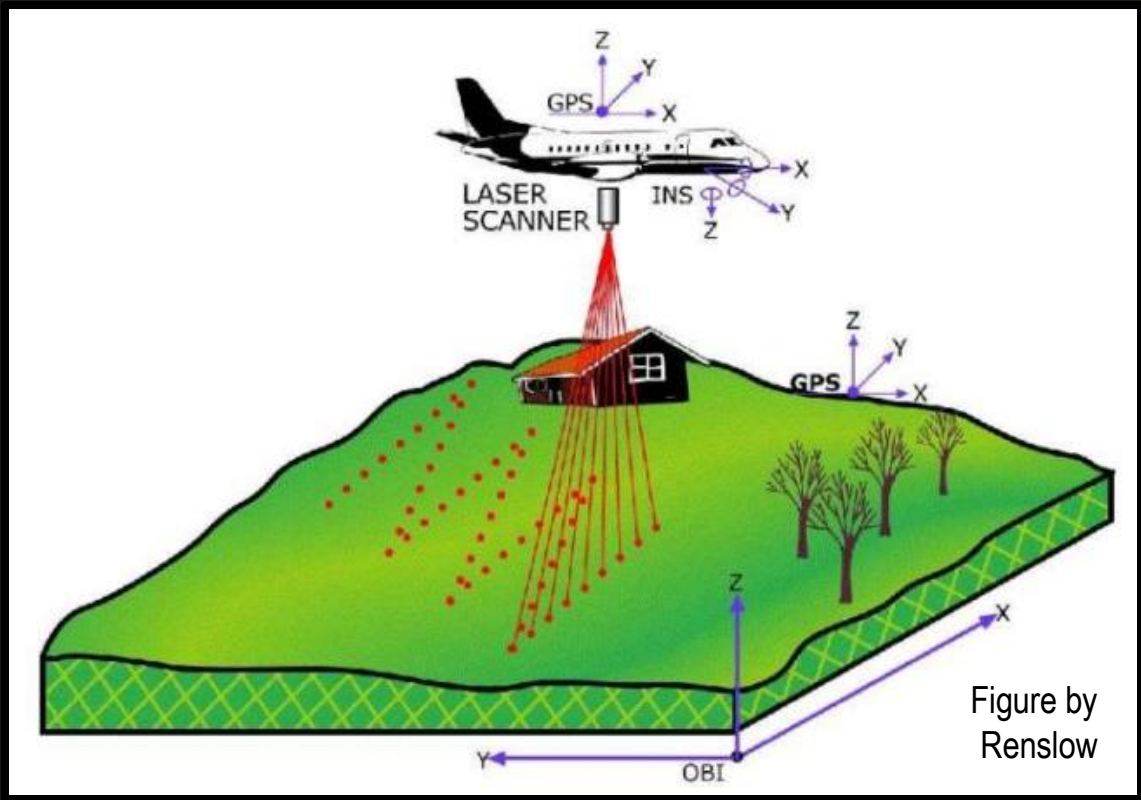


Figure by Renslow

- LiDAR = “Light Detection and Ranging”
- Discrete-return scanning LiDAR [1]
  - 900-1,600 nm wavelength
  - > 4 pulses / m²

[1]Skowronski et al. 2007. Remote Sens. Environ. 108: 123-129.

Methods

LiDAR Survey

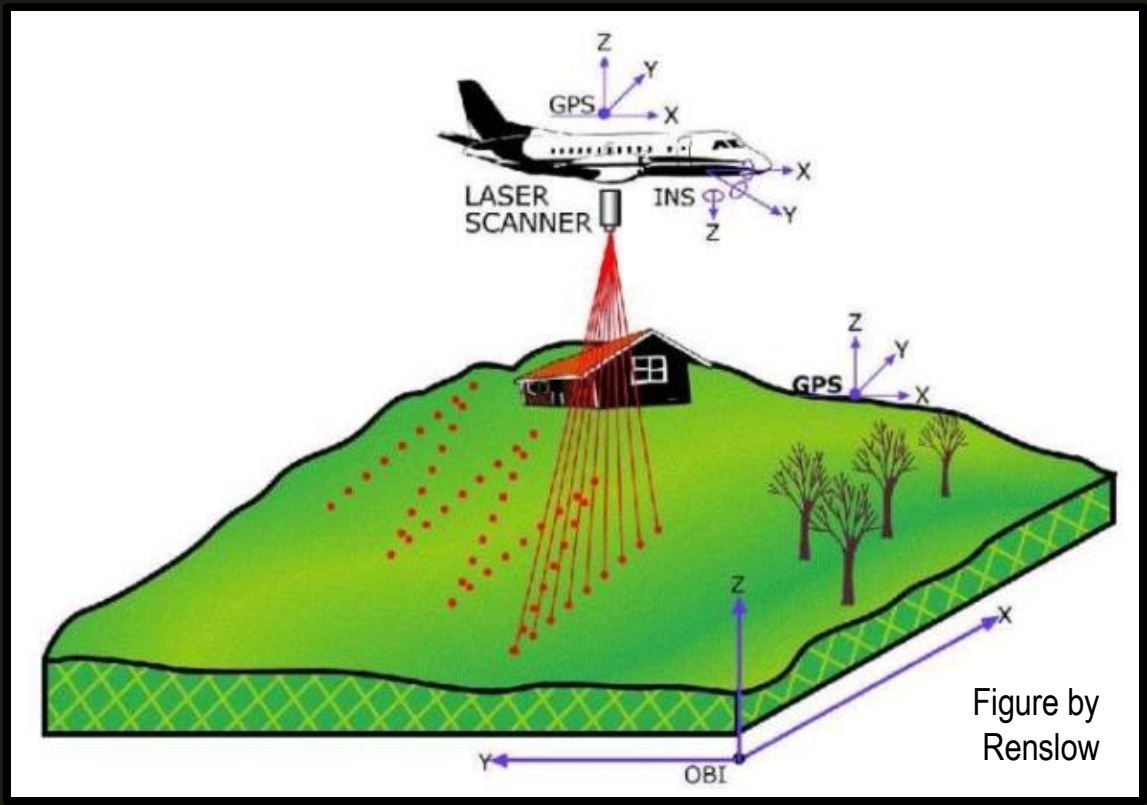


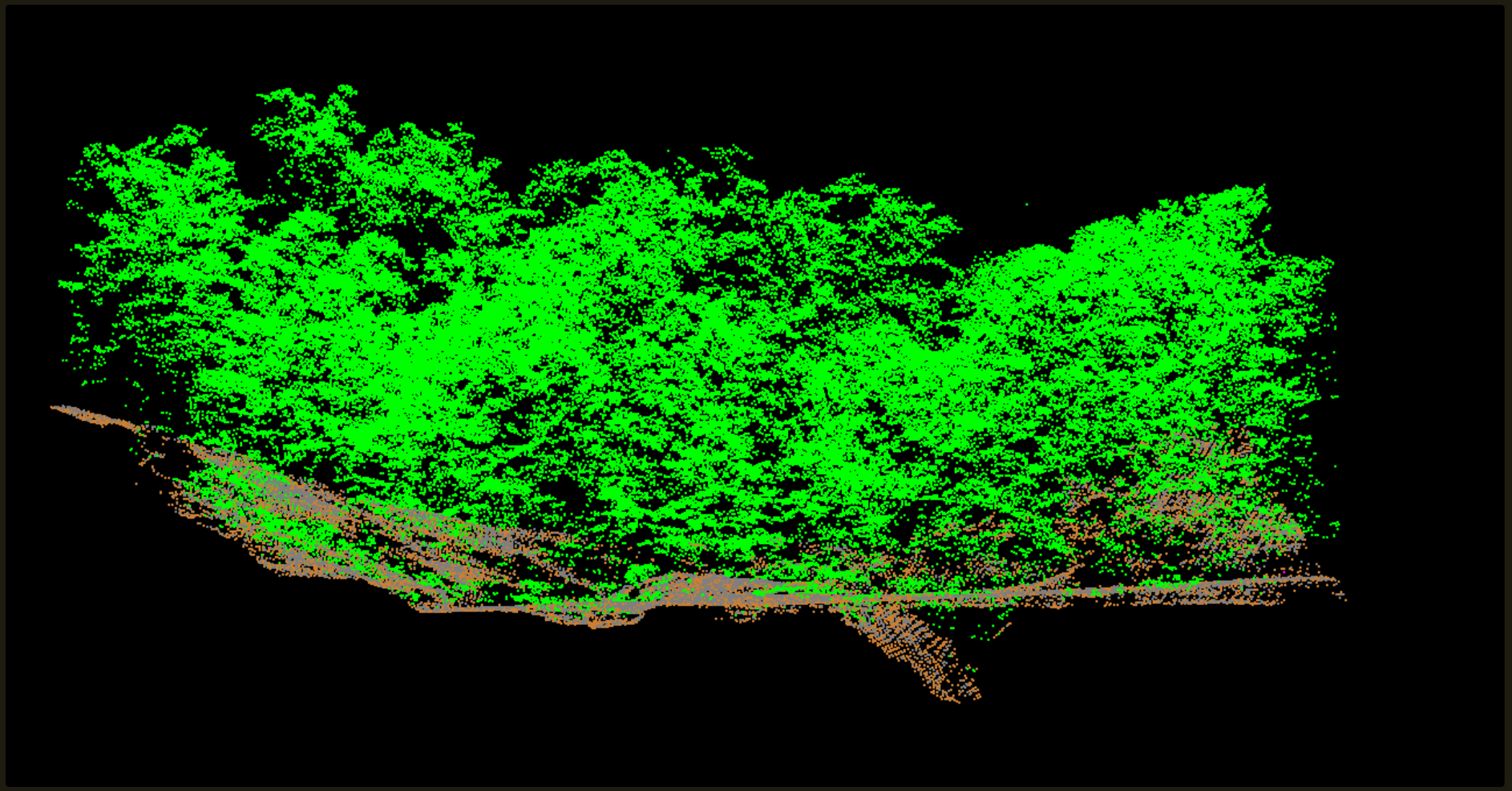
Figure by Renslow

- LiDAR = “Light Detection and Ranging”
- Data collected Oct 2010 (leaf-off) via fixed-wing aircraft

Methods

- What scale is meaningful?

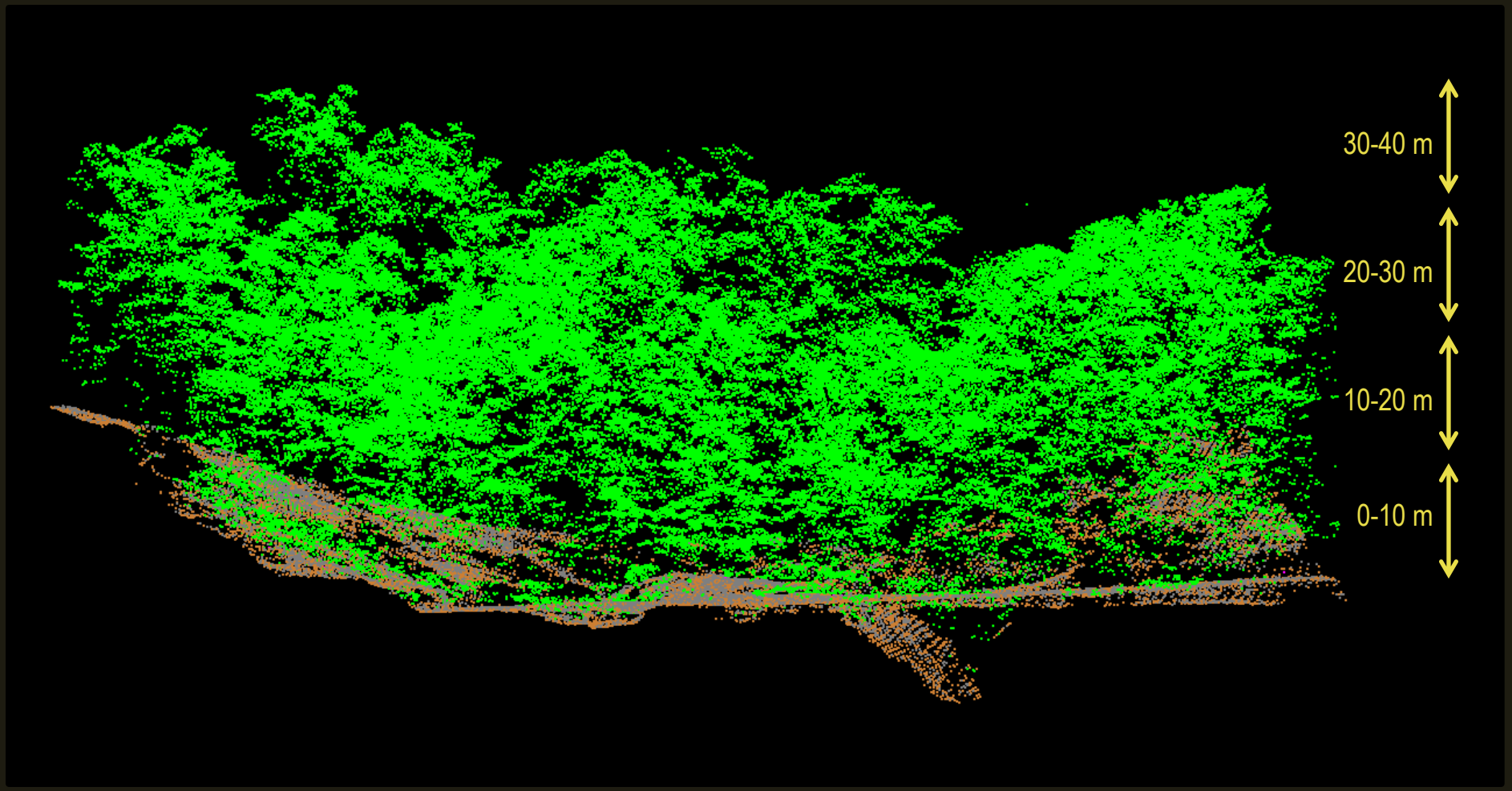
LiDAR Variables



Methods

LiDAR Variables

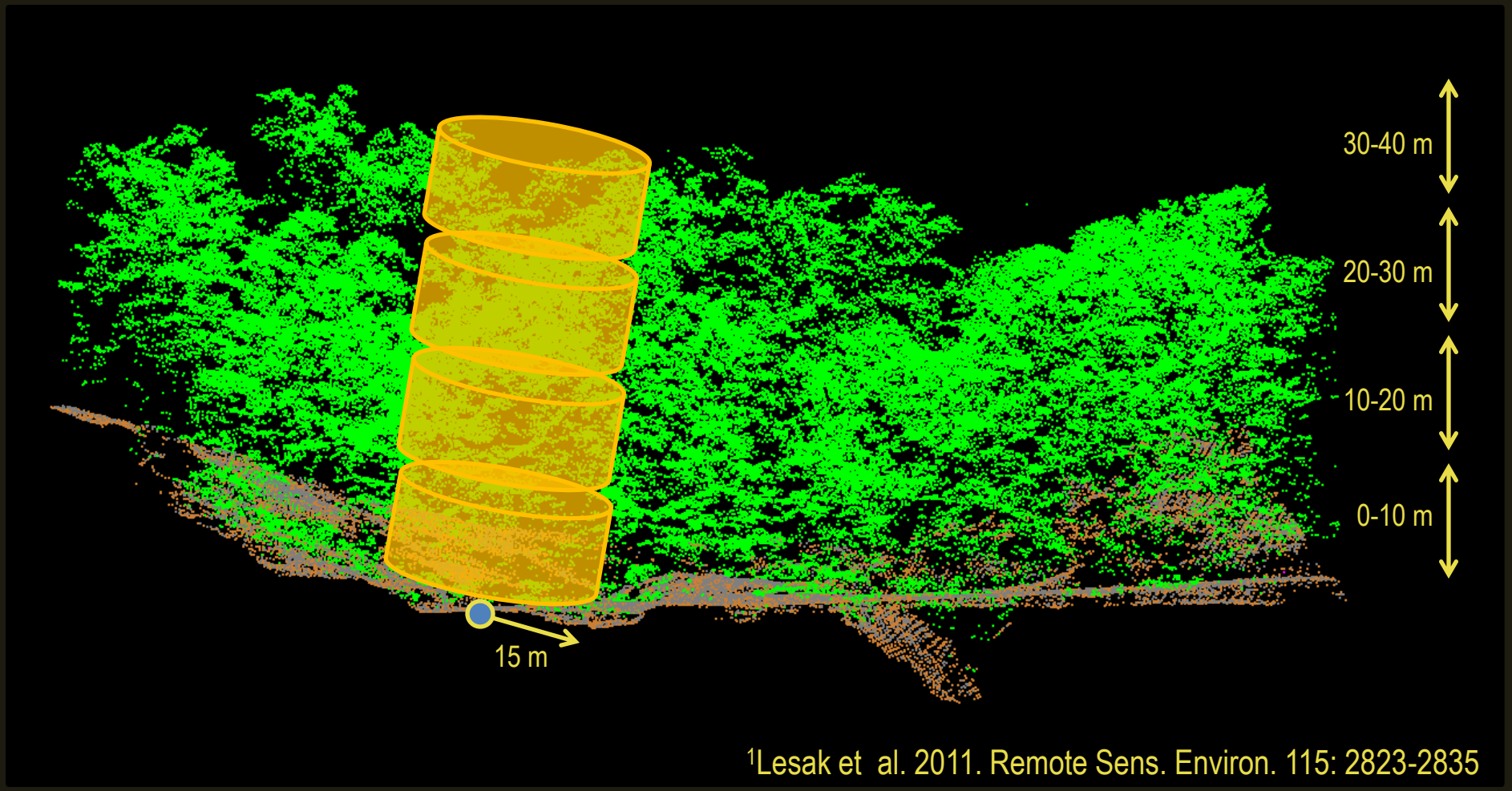
- What scale is meaningful?
- Laser returns across 10 m strata



Methods

LiDAR Variables

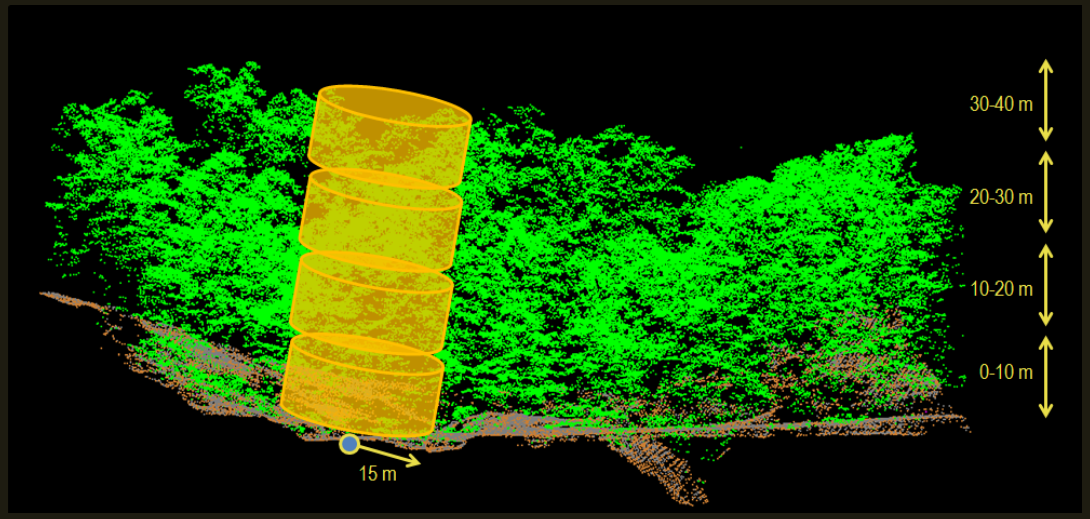
- What scale is meaningful?
- Laser returns across 10 m strata
- 15 m radii around trap locations[1]



[1]Lesak et al. 2011. Remote Sens. Environ. 115: 2823-2835

Methods

LiDAR Variables



- 0-10 m CHP
- 10-20 m CHP
- 20-30 m CHP
- 30-42 m CHP
- Understory Ratio
  - 0-10 m CHP / Total CHP
  - Indicator of canopy “shape”

Methods

LiDAR Variables

- 0-10 m CHP
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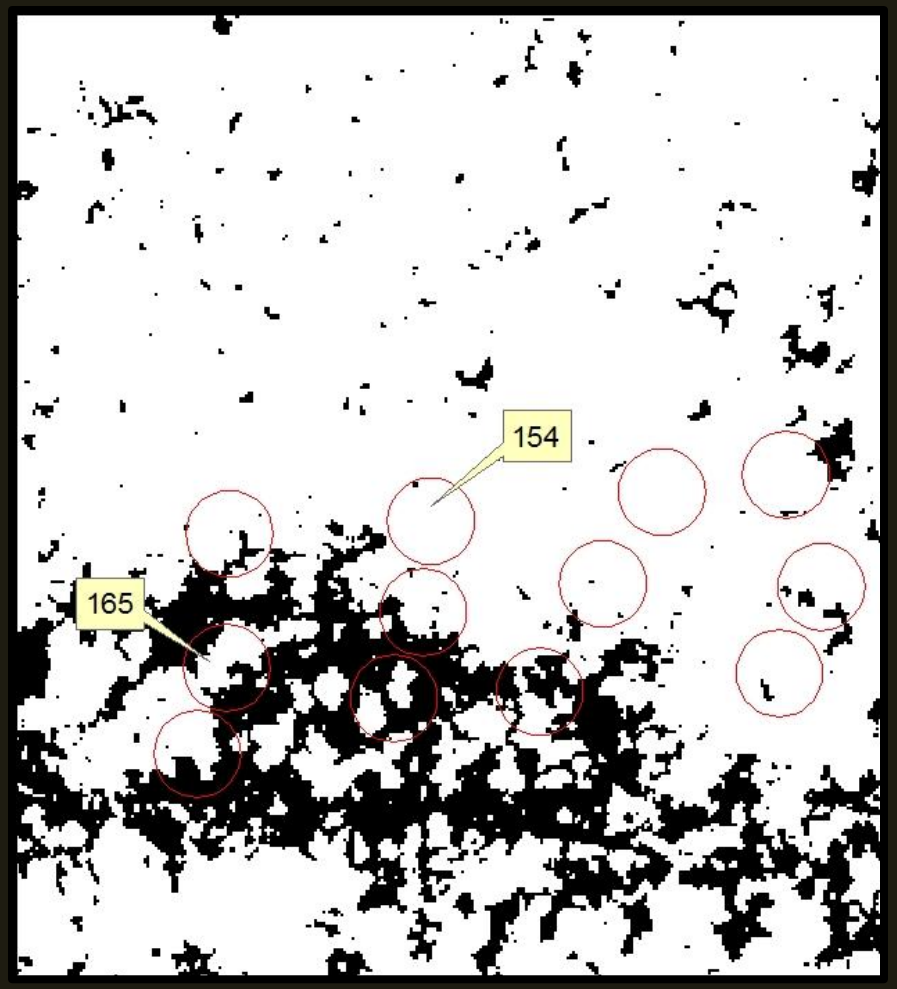
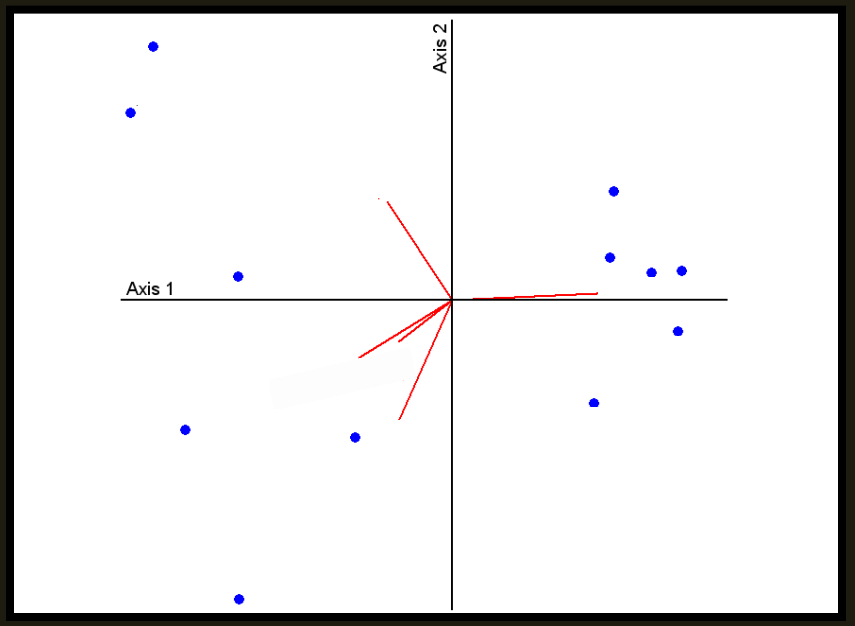


- Gap Index
  - Percentage of pixels with no laser returns >3 m height

Analysis
Moth + LiDAR



- Today's talk… Canonical Correspondence Analysis
  - Standard ordination techniques following ter Braak[1]
  - PC-ORD v. 4.25; default settings; 300 iterations

- Future… Predictive models & landscape maps

[1]McCune & Grace. 2002. Analysis of Ecological Communities. MJM Software Design

Results

Results

Moth Occurrence

- 24,198 moths
- 535 species
- 28 families

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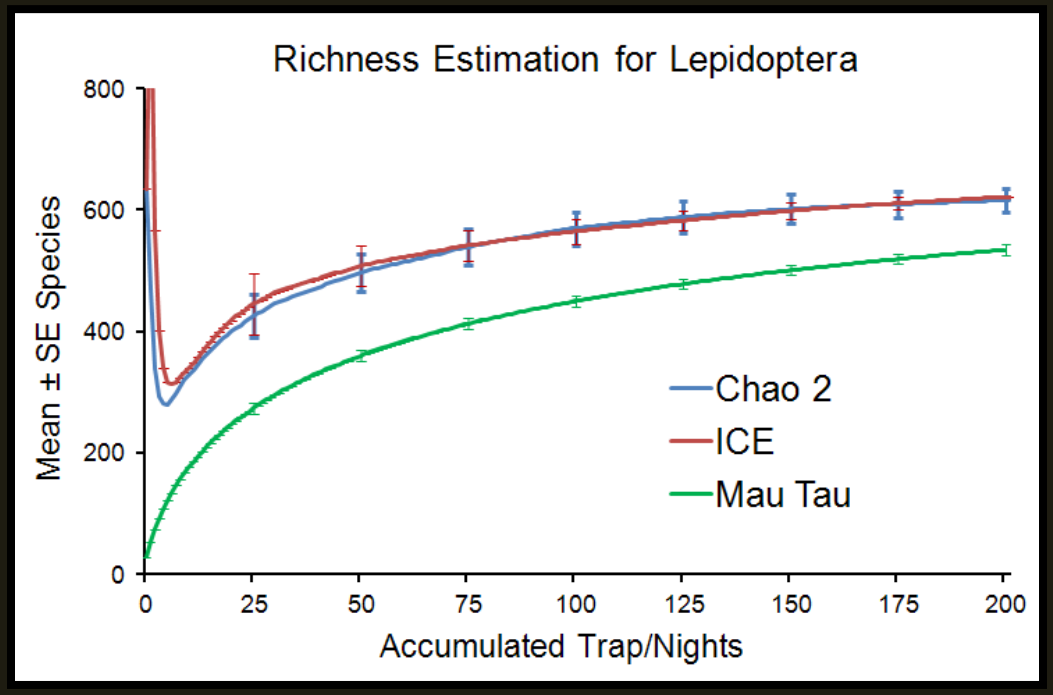
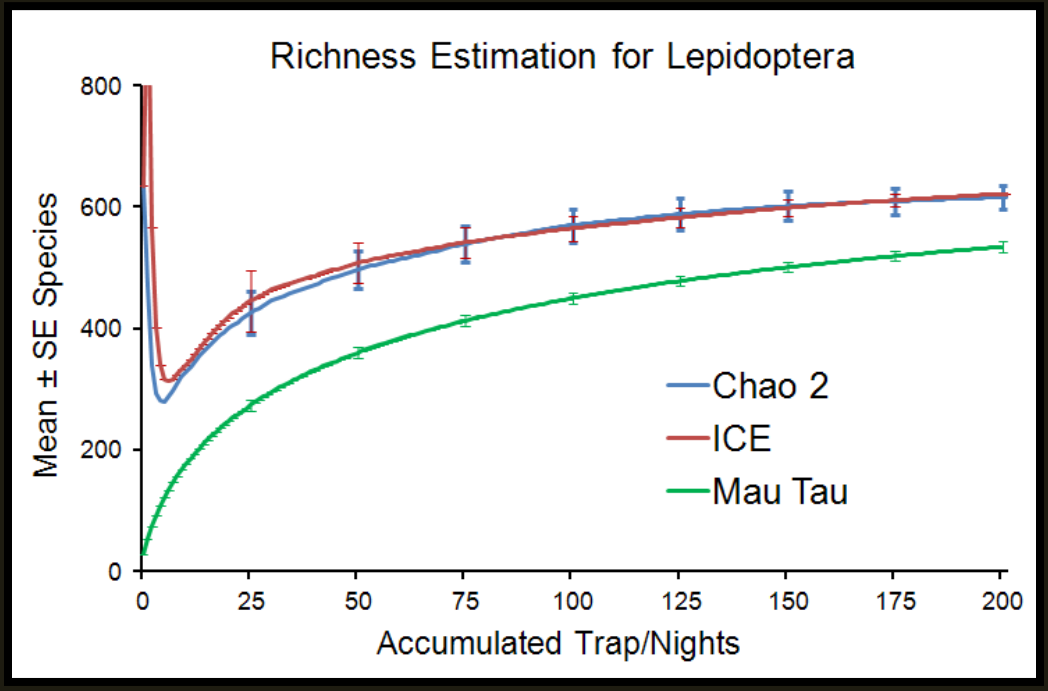


Results

Moth Occurrence

- 24,198 moths
- 535 species
- 28 families
- How much of this assemblage are we accounting for?
  - 86% (vs. ICE)
  - 87% (vs. Chao 2)



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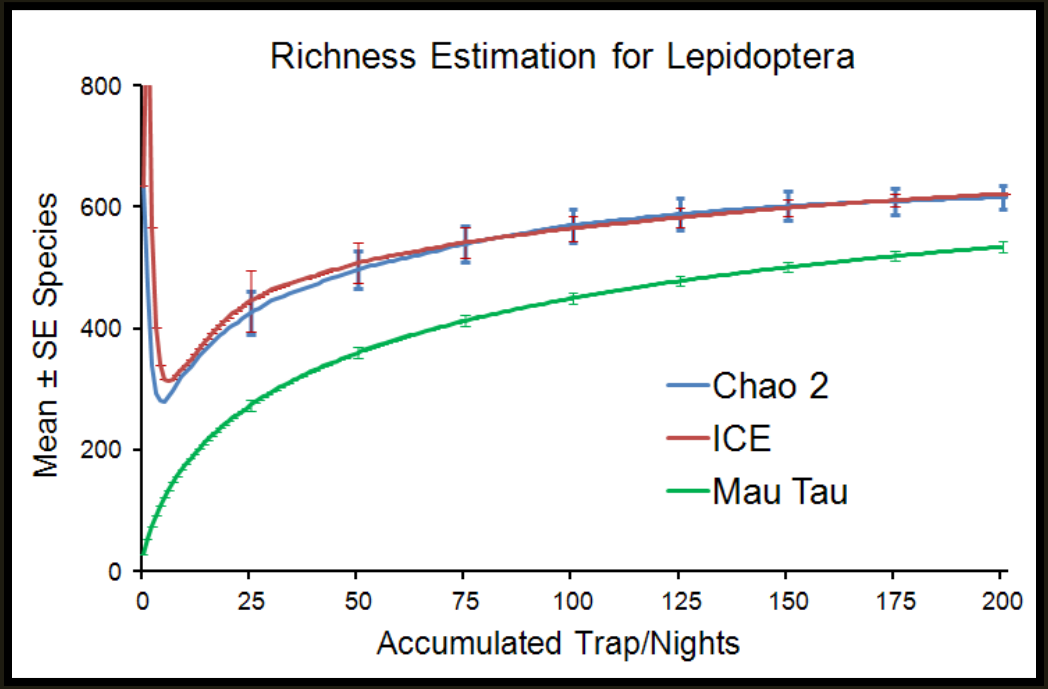


- Most abundant & richest families
  - Erebidae
  - Geometridae
  - Noctuidae
  - Notodontidae
  - Pyralidae

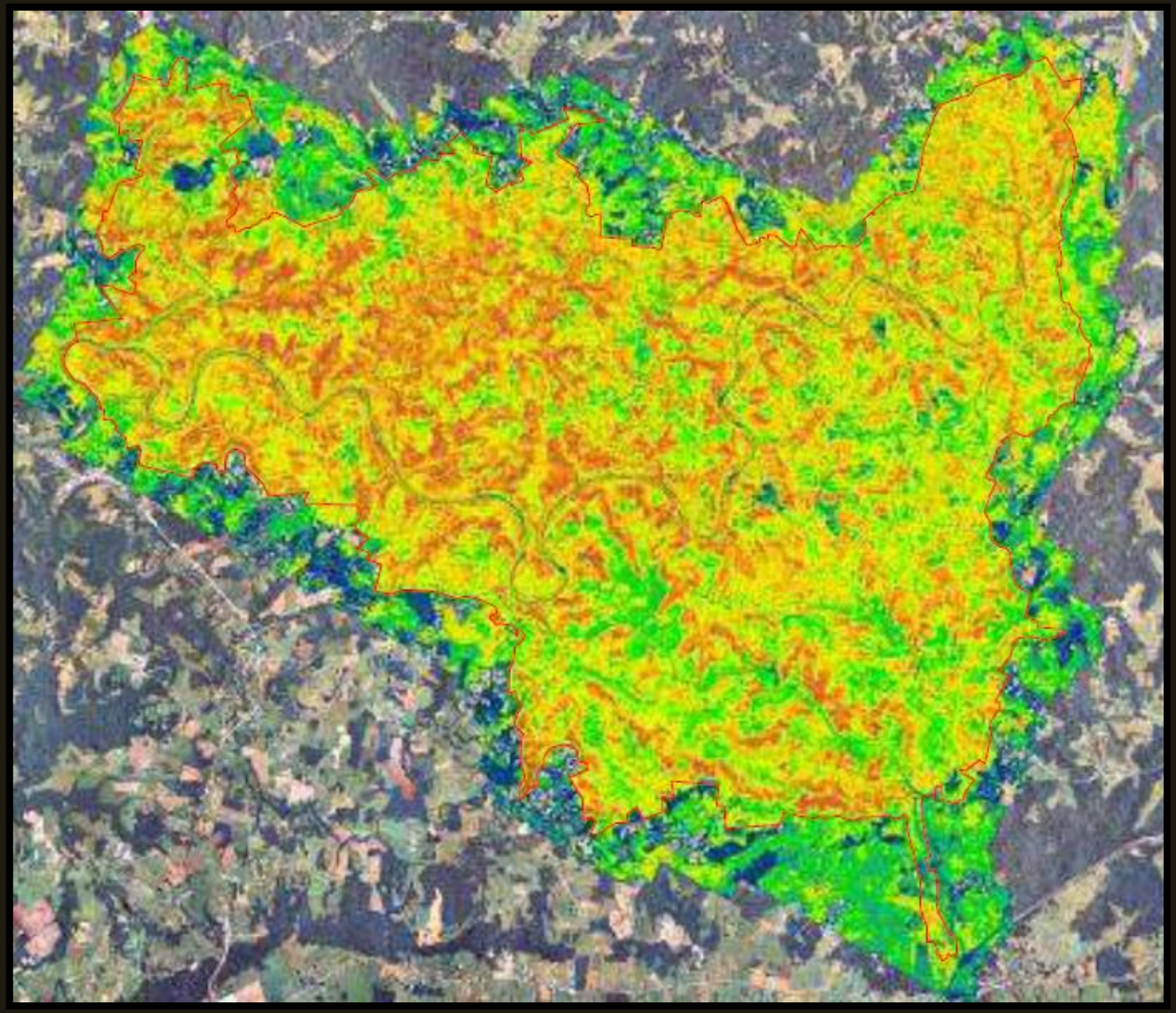
Results

LiDAR

Results

LiDAR

Mean Canopy Height
Blue to Red → Min to Max Height



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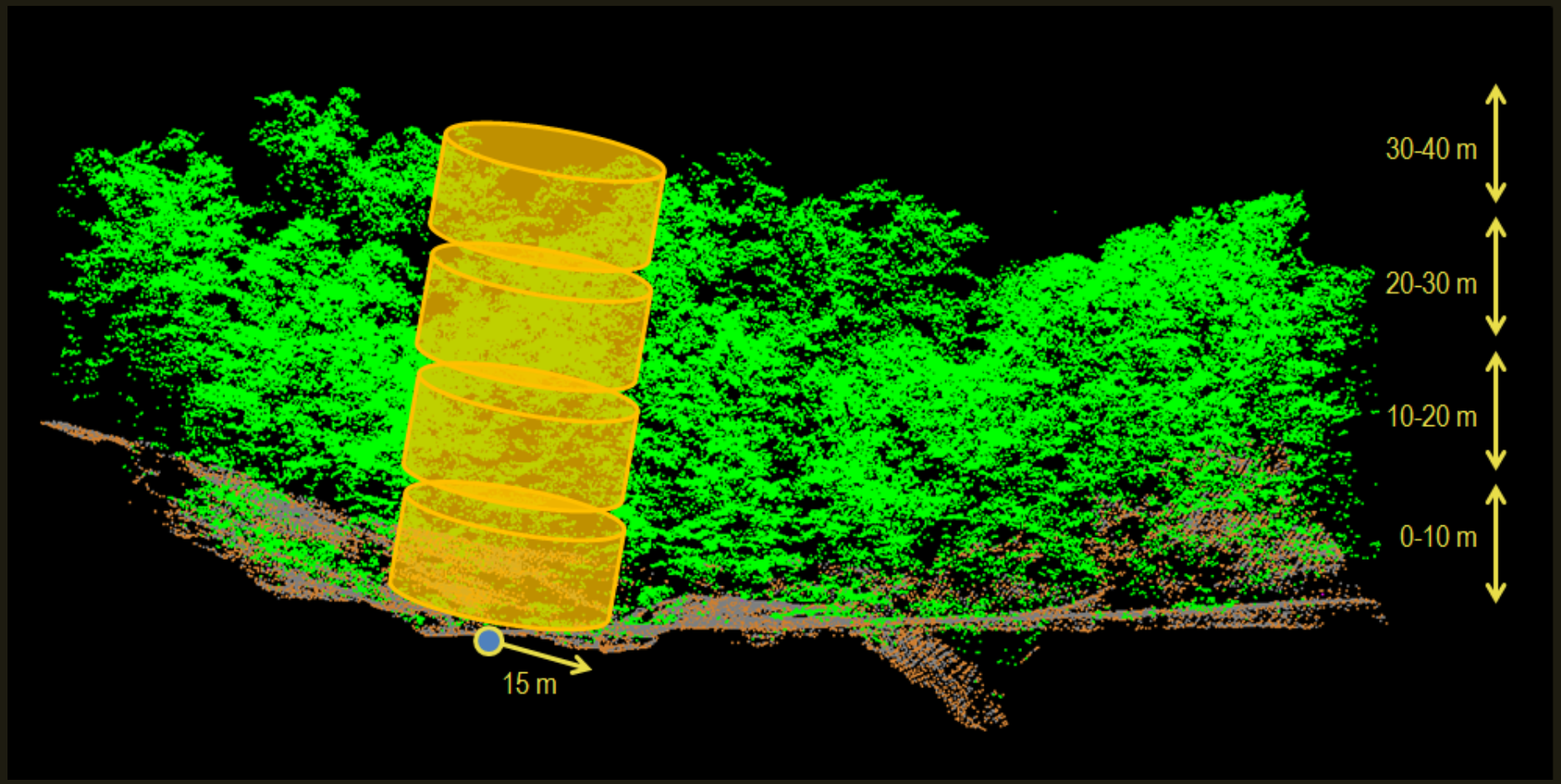
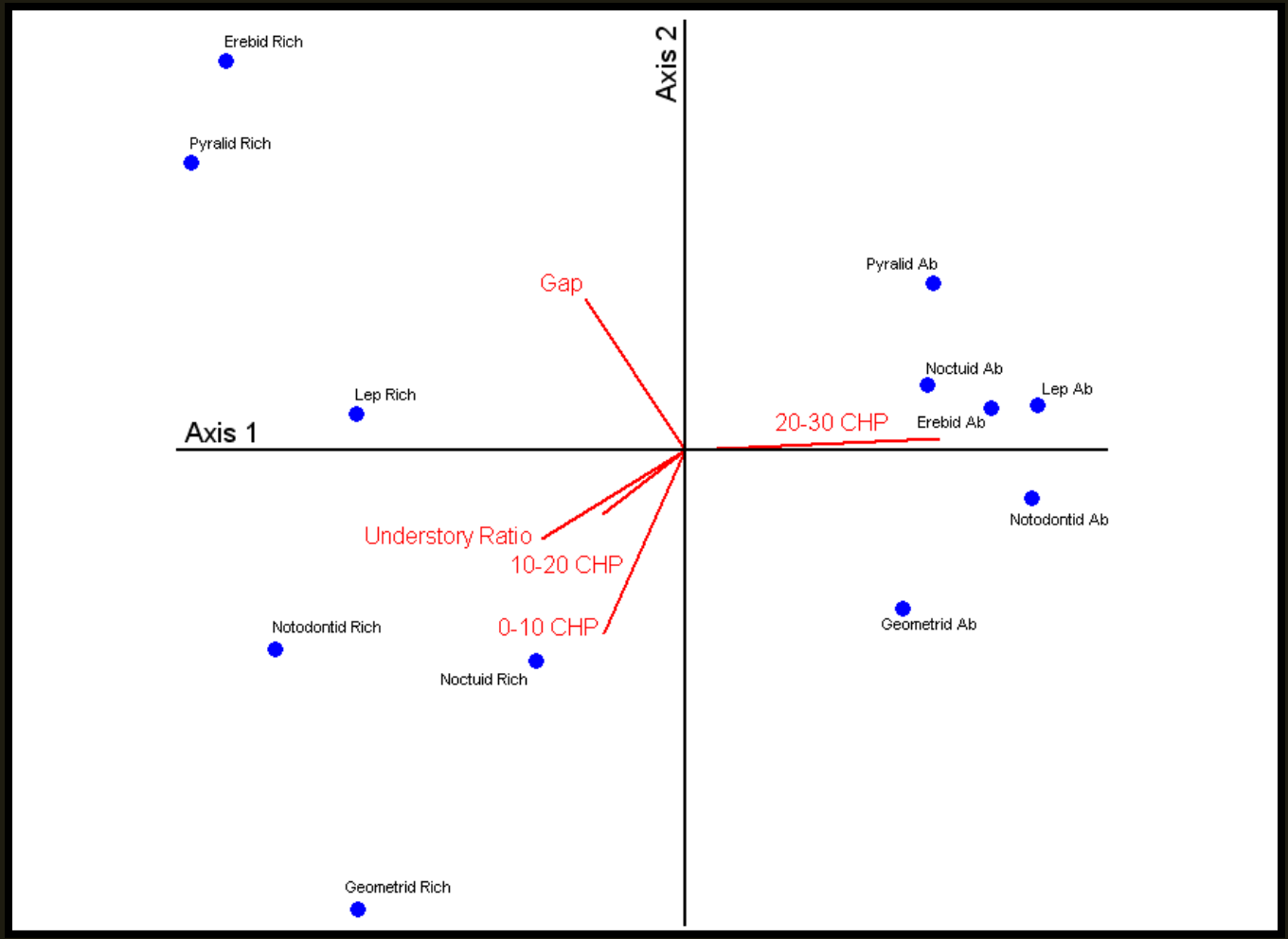


Results

Moths + LiDAR

- 1st & 2nd Axes significant ($P \leq 0.01$)
- 12% dataset's variation explained
- "Inertia" of the dataset: 0.31



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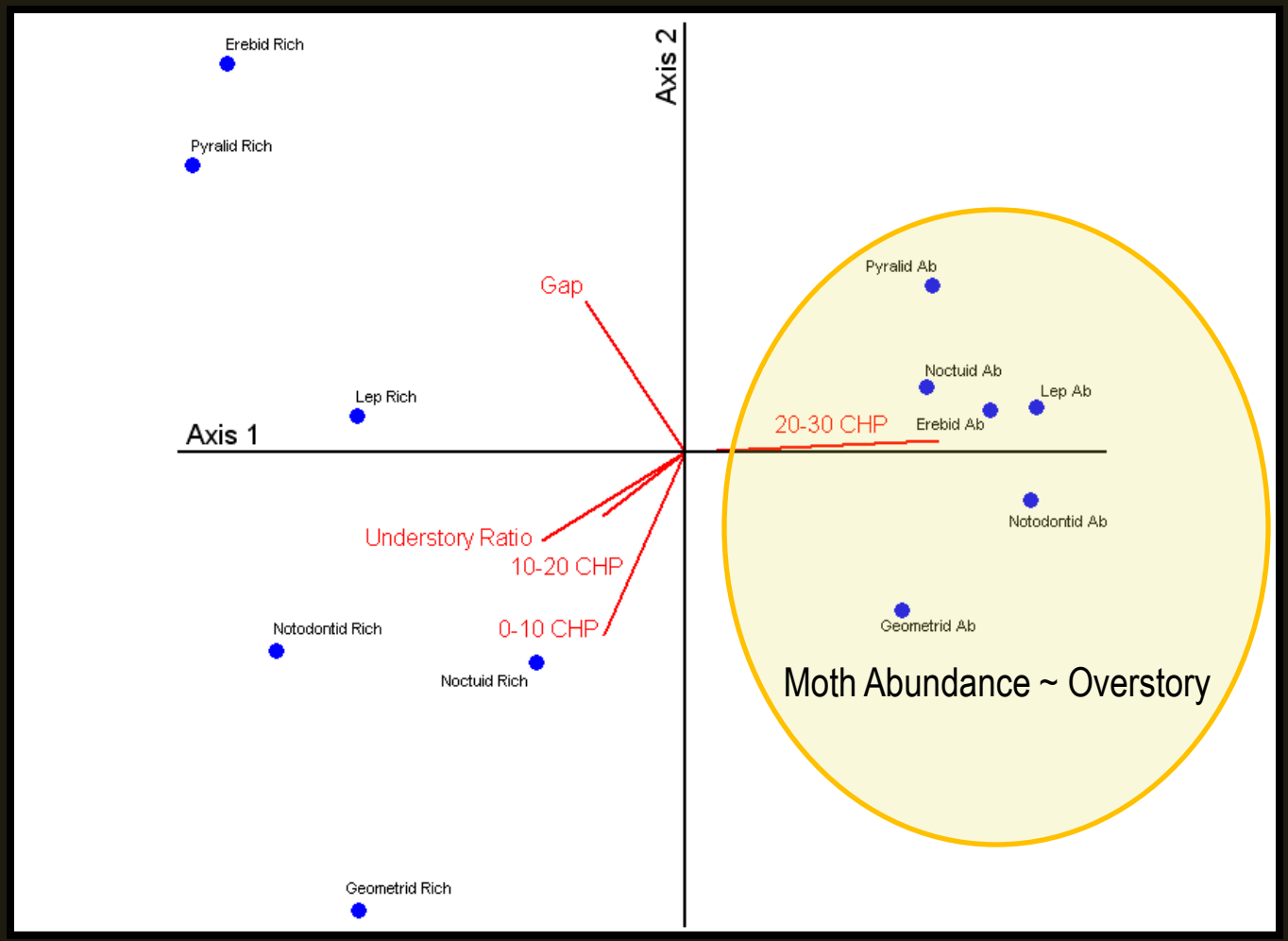

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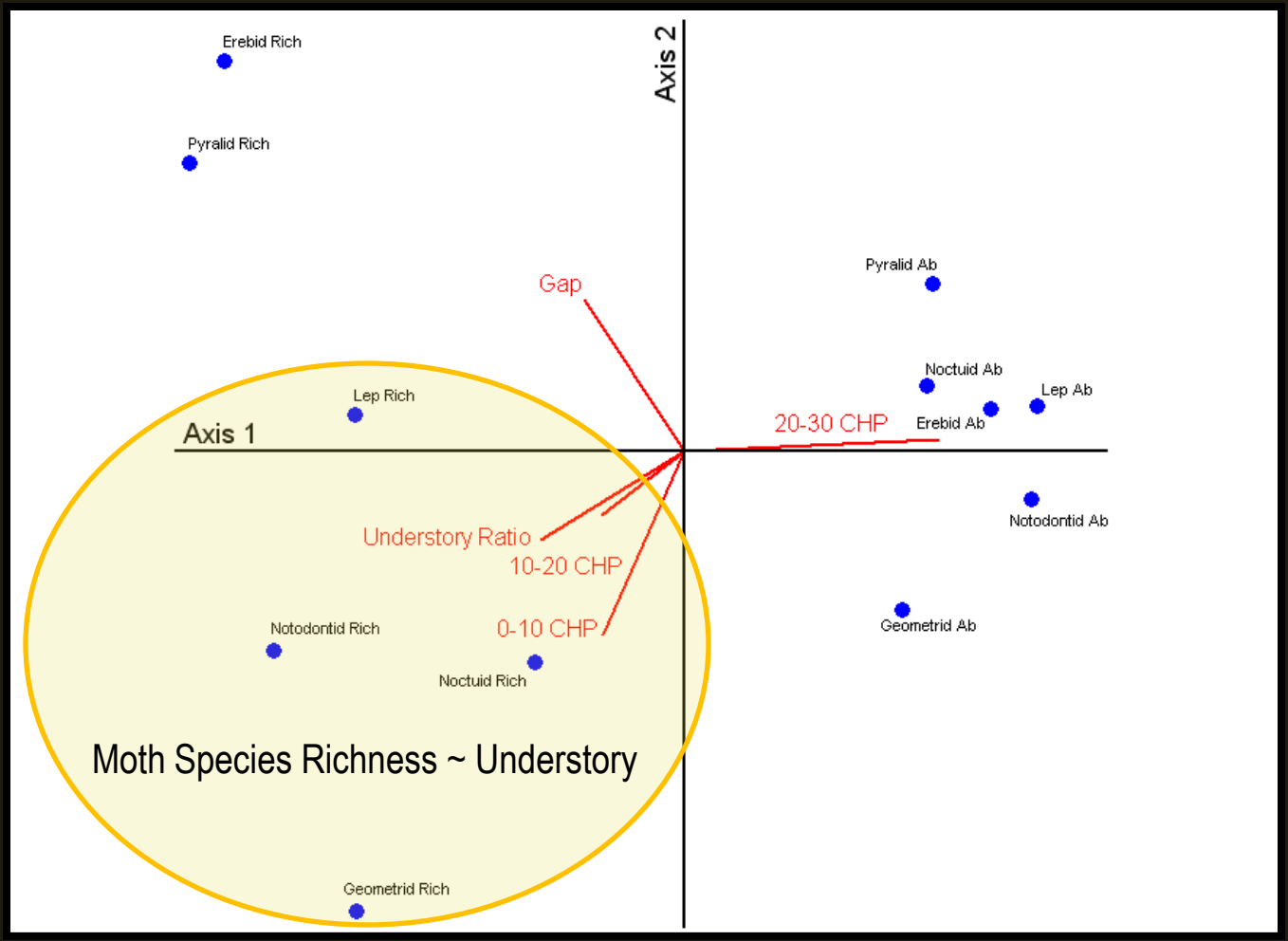

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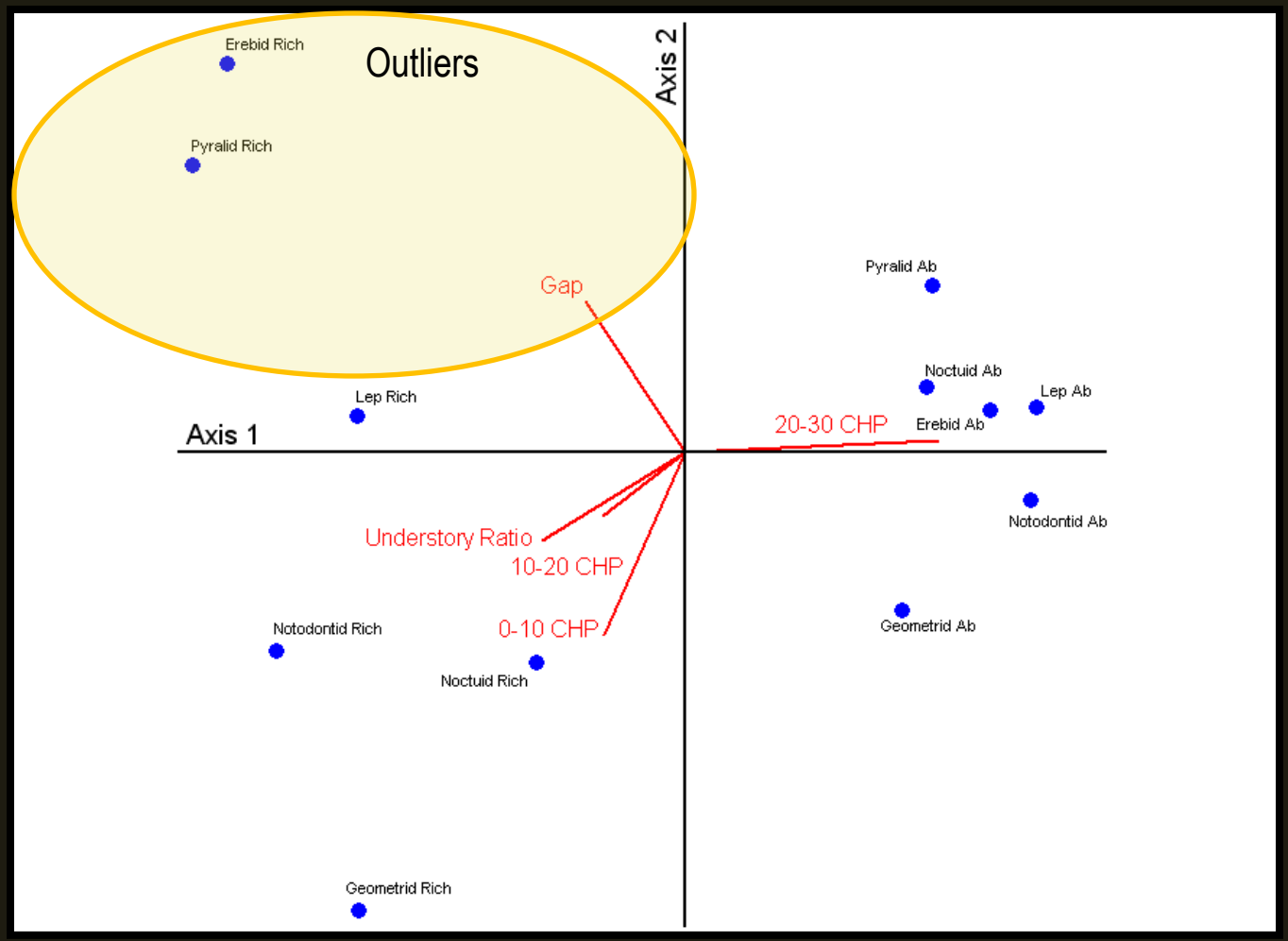

Discussion & Implications

- Findings to date…
  - Abundance associated with overstory
  - Diversity associated with understory

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  - Abundance associated with overstory
  - Diversity associated with understory

- Lep diversity driven by floral diversity in the understory
  - Riparian habitats[1,2]
  - Logged upland sites[3]

[1]Ober & Hayes. 2010. Biodivers. Conserv. 19: 761-774
[2]Dodd et al. 2011. J. Kansas Entomol. Soc. 84: 271-284.
[3]Dodd et al. 2012. Forest Ecol. Manage. 267: 262-270.

Discussion & Implications

- Findings to date…
  - Abundance associated with overstory
  - Diversity associated with understory

- How does occurrence of prey mesh with the predators?
  - Habitat structure vs. prey availability[1,2,3]

[1]Morris et al. 2010. J. Wildlife Manage. 74: 26-34.
[2]Dodd et al. 2012. Forest Ecol. Manage. 267: 262-270.
[3]Muller et al. 2012. Oecologia 169: 673-684.

Discussion & Implications

- Findings to date…
  - Abundance associated with overstory
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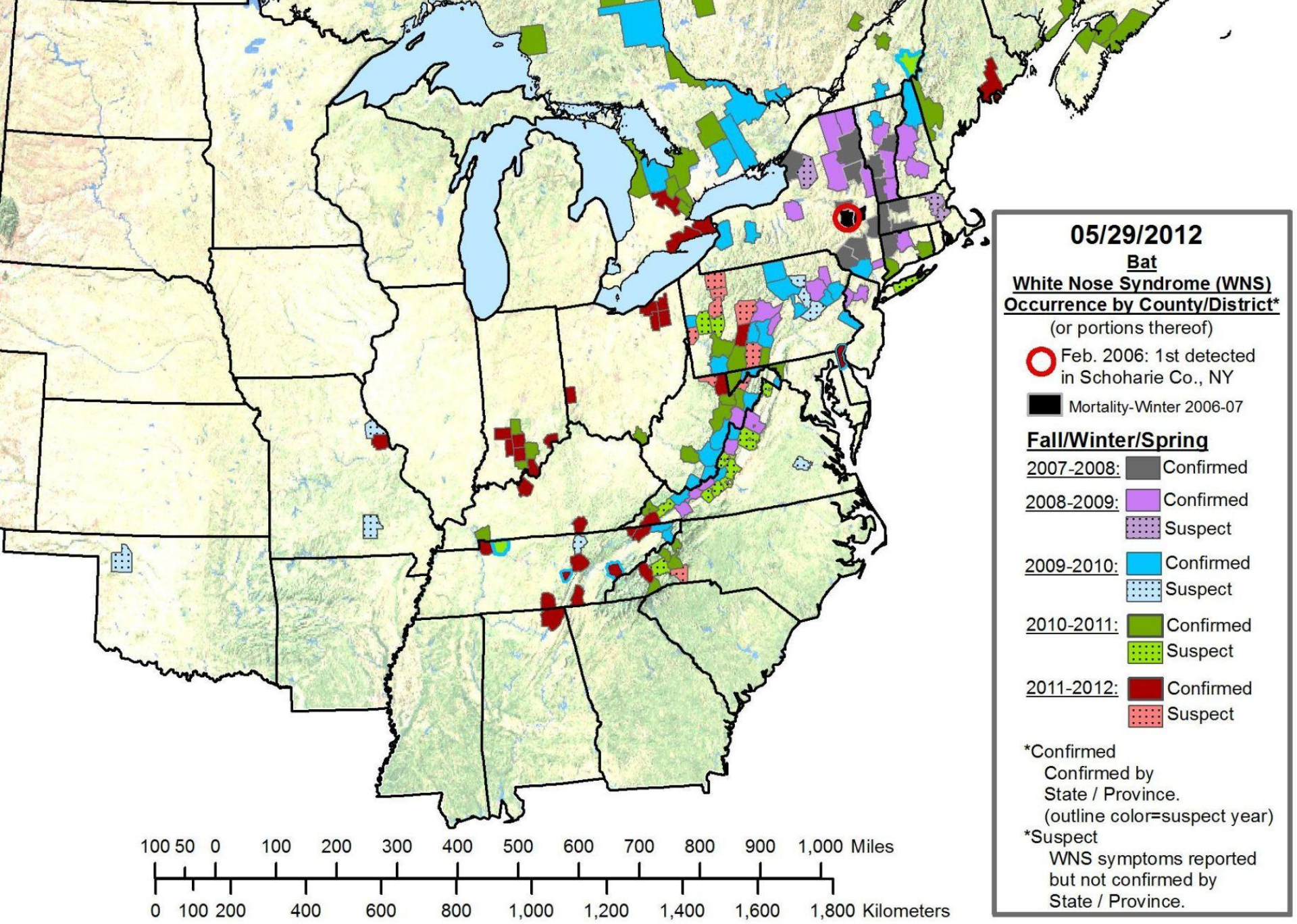
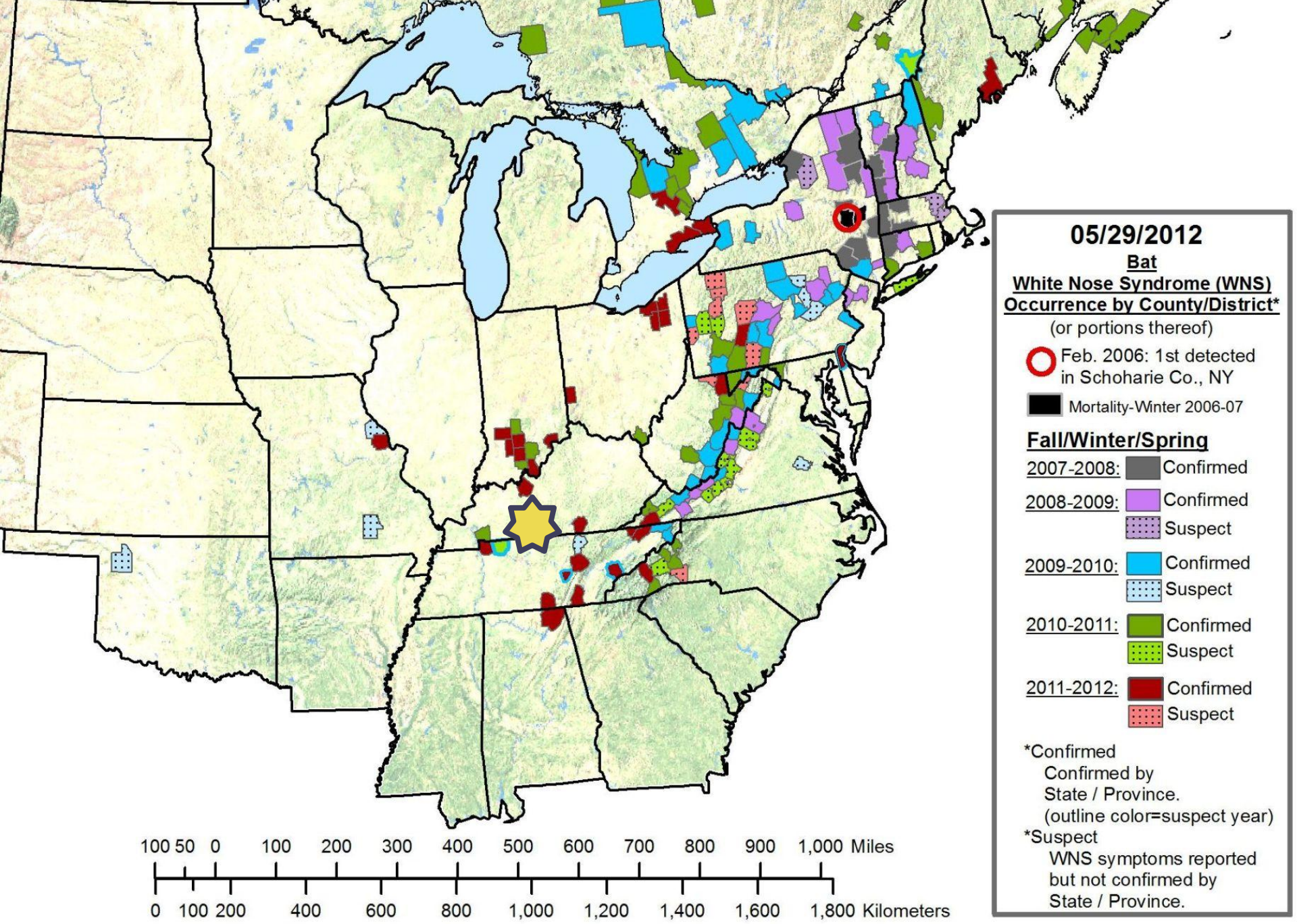
- How does occurrence of prey mesh with the predators?
  - Habitat structure vs. prey availability[1,2,3]
  - What happens if/when White-nose syndrome hits?



Map by: Cal Butchkoski, PA Game Commission



Map by: Cal Butchkoski, PA Game Commission

Thanks!

- Funding
  - Joint Fire Science Program

- NPS Personnel
  - Dr. Rick Toomey
  - Steve Thomas

- Tech Support!
  - Tracy Culbertson
  - Klint Rose
  - Jennifer Winters


2011 Tech Support


2010 Tech Support